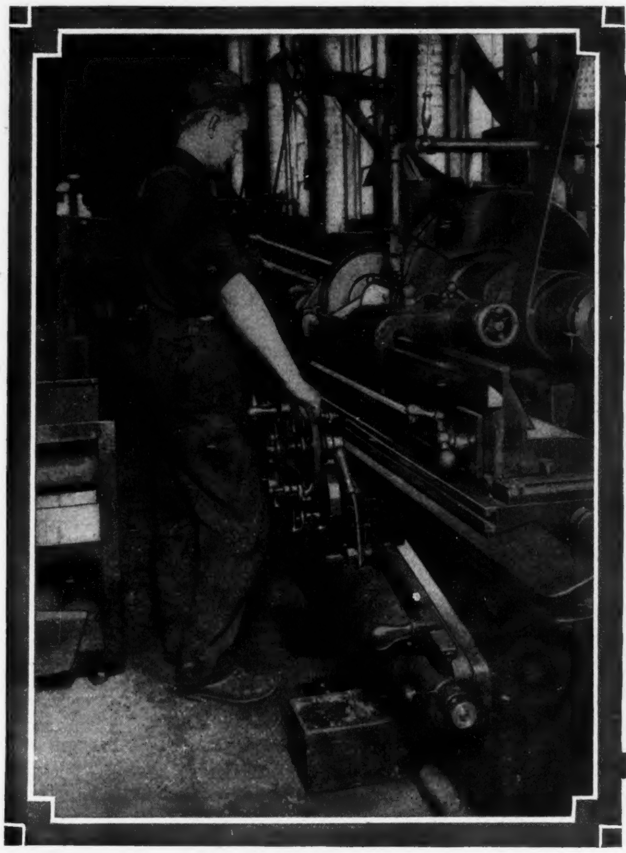


Plain Cylindrical External Grinding*

Development, Methods of Handling and Examples of Work

by Douglas T. Hamilton†

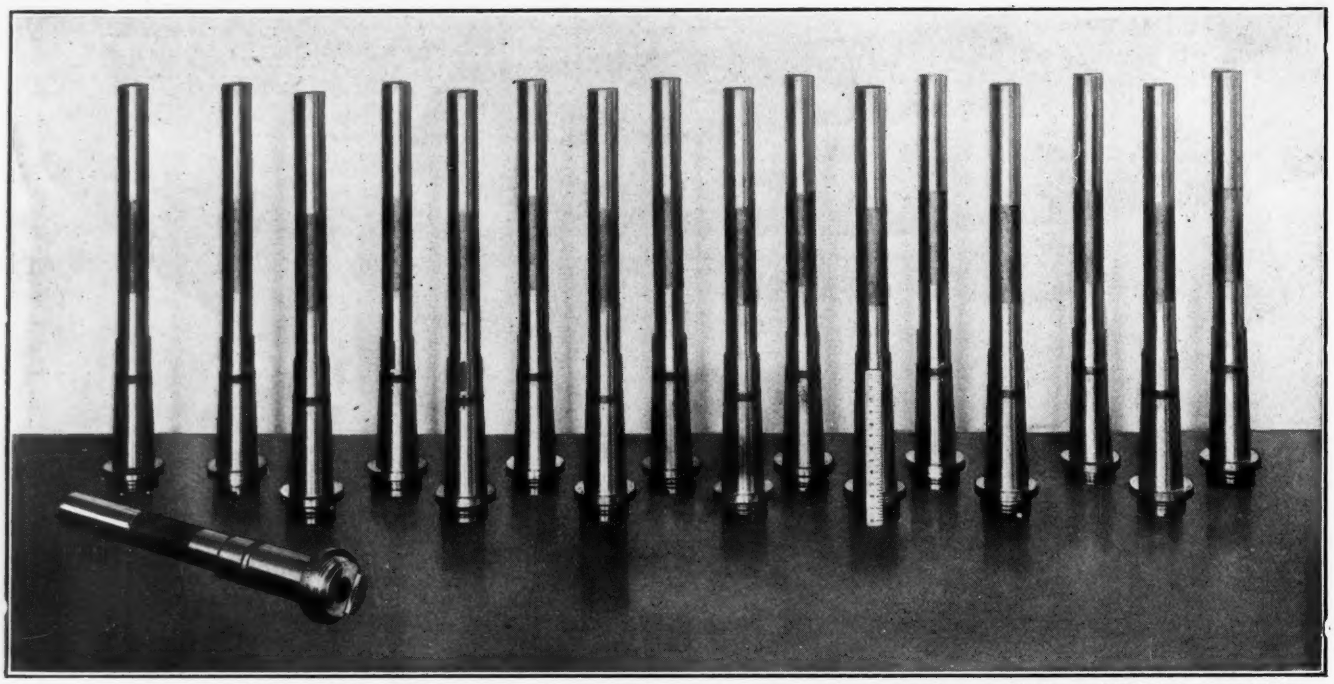
PLAIN cylindrical grinding is regarded quite differently today from what it was years ago when grinding was first accomplished. The first commercial grinding machine, built in 1864-1865, was used only as a precision machine for grinding hardened parts and correcting slight errors due to warping in hardening. From this small beginning, the grinding machine has passed through a remarkable development which has resulted in greater stability and convenience of operation. Generally speaking, there are two classes of plain cylindrical grinding; one is the occasional grinding of a hardened part in the tool-room, and the other the manufacturing of parts in large quantities to accurate dimensions. In the first case, the question of cost is not a vital factor of the problem, although it should always be considered, but accuracy is of paramount importance. In the second case, the cost is vital, and when we consider that the work also has to be manufactured within certain limits—in most cases extremely close—the importance of the problem is appreciated.

A grinding machine that would be suitable for grinding work in the tool-room would, in many cases, be entirely unsuited for manufacturing parts in large quantities. A tool-room machine is more adapted to universal requirements, and consequently is provided with features that are not needed in straight manufacturing work, where sufficient quantities of one part are required to demand the use of a special machine for the work. At present, far more manufacturing work is being done, of course, than tool work, and consequently greater interest is taken in what might be termed "manufacturing grinding operations." In the following article, therefore, certain phases only of tool-room grinding will be briefly touched upon, the greater portion of the data covering operations dealing principally with work that must be made in large quantities and to accurate dimensions.

The grinding of machine and automobile parts in large quantities brings up several interesting problems in interchangeable manufacture. In the first place, accurate finish must be obtained, and in the second place a large production is generally, if not always, necessary. It is therefore essential that the very best and most practical method be adopted. In practice, for grinding cylindrical work, the wheel is traversed past the work—in some machines the work is traversed past the wheel—and a comparatively wide face grinding wheel is used. The development in grinding has been along the lines of increasing the strength and rigidity of the machine and in the use of increased widths of faces of grinding wheels. Improvements have also been made in the abrasive materials used in the manufacture of grinding wheels. When grinding was first done, emery was used almost exclusively for grinding wheels, but at the present time artificial abrasives which are products of the electric furnace are used almost exclusively for automatic machine grinding. The abrasives used, however, depend largely on the character of the work being ground.

* For additional information on grinding, grinding wheels, and allied subjects, see the following articles previously published in MACHINERY: "Holding Roller Bearing Races for Internal Grinding," May, 1915; "Grinding Practice," February, 1915; "Selection of Wheels for Cylindrical Grinding," January, 1915; "The Tolford Ball Grinding Machine"; "Grinding vs. Milling"; "Operation of Grinding Wheels in Machine Grinding"; "Data on Surface and Cylindrical Grinding," December, 1914; "Ring Wheels and Solid Wheels for Disk Grinding"; "Wheels for Cylindrical Grinding," November, 1914; "Grinding and Lapping Small Work"; "Selection of Wheels for Cylindrical Grinding," October, 1914; "Making Aloxite Grinding Wheels," September, 1914; "Lobdell Calender Roll Grinding Machines"; "Work-holding Fixtures for the Vertical Surface Grinder"; "Crankshaft Grinding," August, 1914, engineering edition; "Safety as Applied to Grinding Wheels," July, 1914, engineering edition, and other articles there referred to; "The Use of Photographs in Grinding and Polishing Departments," July, 1914; "Work Speeds in Grinding," April, 1914; "Machining Armature Shafts," February, 1914; "Grinding Wheel Protection Devices," January, 1914, engineering edition; "Fixture for Grinding Valve Push Rods," June, 1913; "Exhaust System for Grinding, Polishing and Buffing Wheels"; "A Three-Point Micrometer and Its Use," May, 1913; "Efficient Grinding of Cylindrical Work," December, 1912; "Commercial Grinding," October, 1912; "Grinding Calender Rolls," August, 1912; "Grinding and Corrugating Flour Mill Rolls," July, 1912; "Internal Grinding Practice in Hardinge Bros. Shop," May, 1912; "Holding Work for Grinding"; "Efficiency in Cylindrical Grinding," March, 1912; "Grinding Aluminum Castings on a Vertical Spindle Disk Grinder," January, 1912; "Grinding Hardened Gears," September, 1911; "The Field for Grinding—A Comment," July, 1911; "Rough-turning vs. Rough-grinding of Crankshaft Pins," March, 1911; "The Field for Grinding"; "Precision Grinding," January, 1911; "Grinding Adding Machine Side Frames," December, 1910; "Grinding Economy," July, 1910; "History of the Invention of the Universal Grinding Machine," July, 1910, engineering edition; "Grit and Grinding Chips," June, 1910, engineering edition; "Economy in Grinding," May, 1910; "Errors in Grinding Tapered Reamers and Milling Cutters," December, 1909; "Form Grinding Operations in the Shop of the Landis Tool Co.," August, 1909; "Twist Drill Grinding," June, 1909; "Cylindrical Grinding," May, 1909; "Grinder Kinks," December, 1908; "Grinding Threading Chasers for Brass Work," November, 1908; "Devices for Grinding Fluting Cutters," October, 1908; "Helps and Don'ts for Grinding," August, 1908; "Grinding Threading Dies," December, 1907; "Grinding Threading Die Chasers," November, 1907; "Precision Grinding," September, 1907, engineering edition; "The Cost of Grinding," October, 1906.

† Associate Editor of MACHINERY.



This Group of Seventeen Milling Machine Spindles was rough- and finish-ground all over in Twenty-six Hours to Limits of 0.0005 inch, except Two Diameters, which were ground to 0.00025 inch Limits. The Tapers are ground to a Gage

Different Methods of Cylindrical Grinding

Broadly speaking, there are four different methods of applying the wheel to the work when grinding cylindrical work; the first, known as traverse grinding, is shown at *A* and *B* in Fig. 1, and refers to the traversing of the work or wheel by hand or power feed and automatically feeding the wheel in a certain distance at the end of every traverse or at the end of each traverse and return stroke.

The second method, shown at *C*, is known as the "fixed wheel" method. By this method, instead of feeding the wheel in on the work at each traverse, it is fed in to the correct depth determined by a previously set stop, and two traverses made over the work, one being a roughing cut and the other a finishing. This method is also accomplished by leaving the wheel slide "fixed," that is, instead of feeding the wheel in on the work each time a fresh piece is put on the centers, the wheel slide is not adjusted until truing of the wheel has reduced its diameter, necessitating resetting.

The third method, shown at *D*, is known as the "step-in" method of grinding. By this method a comparatively wide face wheel, varying from 2 to 4 inches wide, is stepped-in along the work at intervals, the width of the wheel overlapping until the entire length to be ground has been covered. The wheel is fed in to within from 0.002 to 0.003 inch of the final diameter, and then two rapid traverses are made over the work to complete it.

The fourth and last method is known as "straight-in" or form grinding. This term indicates that the wheel and work remain stationary, as far as lateral adjustment is concerned, and the wheel is fed directly in on the work without any traversing motion. This method of grinding can be used both for the grinding of straight plain surfaces and irregular-shaped form surfaces.

Each of these four methods of grinding has its advantages and limitations. Traverse grinding is recommended on long shafts, say over 2 feet in length, of comparatively small diameter; up to within the last few years this was the only recognized method of plain cylindrical grinding. When the work is short in proportion to its diameter, however, other methods of grinding about to be described have certain advantages over the traversing method. The traversing method, however, is used almost exclusively on grinding machines of light construction and on light accurate work. There are two methods of feeding the wheel in on the work for traverse grinding; one is to feed the wheel in from about 0.0005 to 0.001 inch for every traverse of the wheel past the work, or the work past the wheel, depending on the type of machine used, and the other is to make two traverses of the wheel or work for each feeding-in movement. In rough-grinding, the wheel is fed in a distance varying from 0.0015 to 0.003 inch at each forward stroke, the spring in the material being depended upon to provide for a light cut on the return stroke. For finishing, the wheel is generally fed in about 0.0005 inch at every traverse of the wheel past the work or the work past the wheel, and usually from one to two traverses are made at the finish without any in-feeding of the wheel at all.

The "fixed-wheel" method of grinding on many classes of work supersedes traverse grinding from a production standpoint; for example, short lengths of work—not shoulder shafts—such as bushings, etc., can be economically ground by this method. The practice is to start by feeding the wheel in and traversing over the work until the work has been ground to the final size; then the position of the wheel is fixed, that is, it remains stationary as far as in-feeding is concerned, and for the next piece the wheel is fed straight across the work, taking a heavy cut; then it returns with a light cut, finishing the work to the required diameter.

This method of grinding is hard, of course, on the corner of the wheel, and the practice is generally to true the "feeding side" of the wheel to a slight angle. The extreme edge of the wheel is reduced about 0.030 inch in diameter and the face gradually tapered for about ¼ to ½ inch. As the examples in Figs. 25 to 29, inclusive, will show, this method of grinding is a highly productive one on classes of work for which it is adapted, but it could not be used with any degree of success on extremely long slender shafts because of the liability of chatter and springing of the work, even though it were rigidly supported by steady-rests. It also has a tendency to wear the wheel down rapidly, and difficulty is sometimes experienced in getting a wheel that will not clog or glaze and will still be hard enough to stand up to grind several pieces without retruing or re-setting of the wheel slide. This method, however, is par-

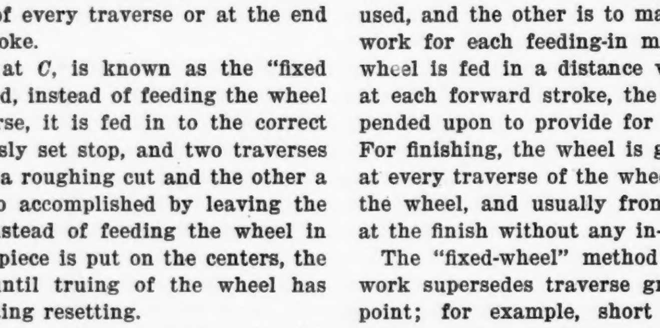


Fig. 1. Diagram illustrating Different Methods of applying Wheel to Work for Cylindrical External Grinding

ticularly adapted to the grinding of bronze and cast-iron bushings, and work of a similar character. As far as the allowance for grinding is concerned, less metal is left on the diameter of the work to be removed by the grinding wheel when the fixed wheel method of grinding is used than when the regular traverse method is employed.

The step-in method of grinding, as previously explained, consists in stepping the wheel in at intervals along the surface of the work to within about 0.001 to 0.003 inch of the finished size, and then making several rapid traverses, generally about two. This method can be used advantageously on comparatively long shafts that are either hard or soft when ground, but is of very little advantage on shoulder shafts or extremely long slender work. Some manufacturers are using this method for grinding parts that others are producing by the straight-in or form method. The step-in method can be used on comparatively light grinding machines that would not stand up to the form wheel proposition; furthermore, wheels of comparatively narrow face as regards those used for form grinding can be used. Generally for step-in grinding, the wheel used is about 2½ to 3 inches width of face, and about ¼ to ½ inch overlapping of the wheel is used for stepping-in along the work. The comparative production figures of work ground by the regular traverse method and that ground by stepping-in along the work show that the step-in method from a production standpoint is superior to the traverse method for certain classes of work. In the illustrations which follow, several very good examples of step-in grinding are given. These will serve to show the classes of work on which this type of grinding can be used to advantage.

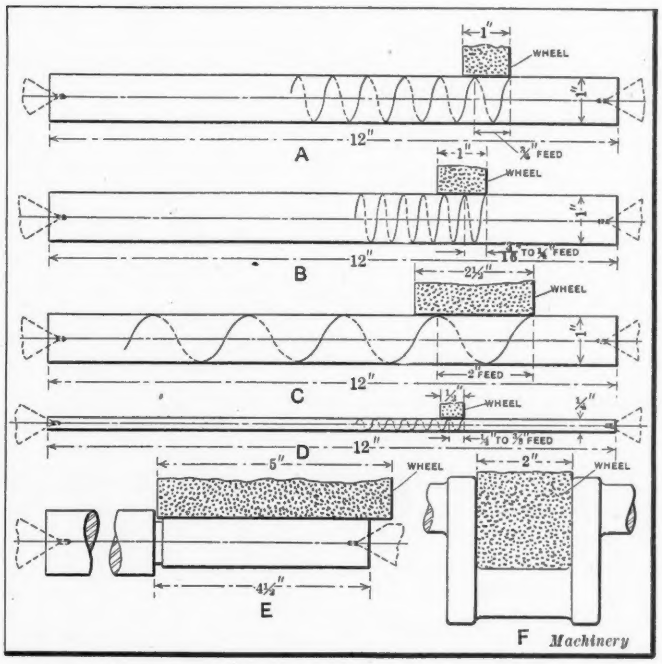


Fig. 2. Diagram illustrating Conditions which govern Width of Face of Grinding Wheels for External Cylindrical Grinding

Form or straight-in grinding is a comparatively recent development of the grinding art, and while form grinding was done about ten years ago, it is only within the last five or six years that it has come into commercial use. To accomplish this work, it has necessitated the entire re-designing of grinding machines and also required considerable investigation into the subject of grinding wheels. This subject is at the present time such an extensive one that it has been thought best to cover it separately, and the reader is referred to the article under this heading. Form grinding has its limitations, of course, as well as its advantages. On work over 10 inches in length, it cannot be used to advantage, and in fact on work of small diameter up to about 6 inches in length, it shows very little advantage as far as production is concerned over traverse grinding. On one particular example of work on which both methods were tried, the following results were obtained. The part ground was 3⅜ inches long and ⅜ inch in diameter. On forty of these pieces the total grinding time was 26 minutes, 26 seconds by the regular traverse method, and 21 minutes, 12 seconds by the straight-in or form method. This is a gain of a little over 5 minutes on forty pieces, but when we take into consideration the comparative cost of the wheel and the greater rigidity required in the machine for form grinding, which of course increases its cost, we find that from an actual cost standpoint, the form method has very little advantage over the regular traverse method on this particular piece of work. The chief reason for this was that the work was slender, of a small diameter and required very careful handling to get the required accuracy, which was 0.00025 inch plus—nothing under. This, of course, is an exceptional case, as will be shown in connection with the article on form grinding which presents many examples that clearly show the advantages of form grinding.

Allowances for External Cylindrical Grinding

The amount of metal to leave on the diameter of a piece for finish by grinding is governed by several conditions, among which might be mentioned: first, finish secured in lathe turning operation; second, condition of work when being ground, whether hard or soft; third, shape of work, whether in the form of a solid shaft or in the form of a thin wall bushing; fourth, when casehardened, the depth to which the casehardening scale penetrates; fifth, length of portion ground in proportion to its diameter; sixth, shape of work, whether plain cylindrical, or having a number of shoulders.

The character of the lathe turning operation preceding grinding has probably more to do with governing the allowance on the diameter for grinding than any other one factor. If the work is turned too close to the finish size before grinding, it is evident that less material will have to be removed by the grinding wheel; but light cuts and fine feeds in turning are not always the most economical way of manufacturing any particular part. On the other hand, if too large an allowance is left for grinding, this also is not economical because a large amount of stock could be more economically removed by rough-turning. In general practice, the part is rough-turned in the lathe, using a round-nose tool at a very coarse feed, of say 1/16 to 1/10 inch per revolution of the work, thus leaving a rough ridged surface. By this method of turning, quite a large limit is allowed because of the coarse feed used, which increases the difficulty of measuring the smallest diameter turned, the measuring tool taking the reading on the tops of the ridges.

Where the work is to be hardened, however, after turning, this method of roughing out is not satisfactory because the piece cannot be depended upon to harden evenly if it has a comparatively rough finish. When the part is to be hardened, therefore, it is necessary to get a smoother finish so that no extra allowance need be made in most cases whether the part is to be hardened or left soft previous to grinding.

The amount of stock that can be economically removed by grinding also depends to a certain extent upon the size and power of the grinding machine used. Where a very powerful and rigid grinding machine is used, carrying a comparatively wide-face wheel, considerable stock can be removed by the grinding machine. For ordinary commercial grinding on shaft work, the work is generally reduced in the lathe to within somewhere between 1/64 and 3/64 inch of the required diameter. When the diameter has been rough-turned to these dimensions, it is much more economical to remove the stock by grinding

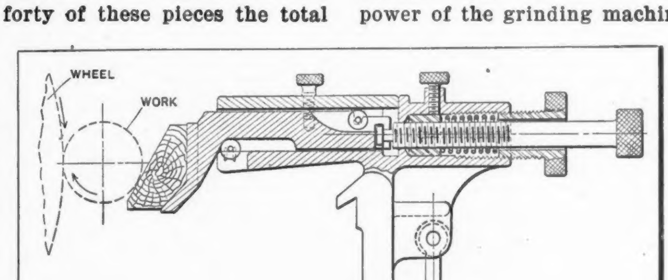


Fig. 3. Plain Type of Steadyrest used principally on Universal Grinding Machine

TABLE I. ALLOWANCES FOR EXTERNAL CYLINDRICAL GRINDING—ALL MATERIALS

Diameter of Work in Inches	Length of Work in Inches													
	2	4	6	8	10	14	18	24	30	36	42	48	54	60
1/8	0.006	0.007	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1/4	0.006	0.008	0.010	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
3/8	0.007	0.008	0.010	0.012	0.013	.....	.....	.....	.....	.....	.....	.....	.....	.....
1/2	0.008	0.009	0.011	0.012	0.013	0.015	0.016	.....	.....	.....	.....	.....	.....	.....
3/4	0.008	0.009	0.011	0.013	0.014	0.016	0.017	0.018	.....	.....	.....	.....	.....	.....
1	0.009	0.010	0.012	0.013	0.014	0.016	0.018	0.019	0.020	.....	.....	.....	.....	.....
1 1/4	0.009	0.011	0.012	0.014	0.015	0.017	0.018	0.019	0.020	0.022	.....	.....	.....	.....
1 1/2	0.010	0.011	0.013	0.014	0.016	0.017	0.018	0.019	0.021	0.023	0.024	.....	.....	.....
1 3/4	0.011	0.012	0.013	0.015	0.016	0.018	0.019	0.020	0.022	0.023	0.025	0.026	.	.....
2	0.012	0.013	0.014	0.016	0.017	0.018	0.019	0.021	0.022	0.024	0.026	0.027	0.028	.....
2 1/2	0.013	0.015	0.016	0.017	0.018	0.019	0.020	0.022	0.023	0.025	0.027	0.028	0.030	0.032
3	0.015	0.016	0.017	0.018	0.019	0.020	0.022	0.024	0.025	0.027	0.028	0.030	0.032	0.034
3 1/2	0.016	0.017	0.018	0.019	0.020	0.022	0.023	0.025	0.027	0.028	0.030	0.032	0.034	0.035
4	0.017	0.018	0.019	0.020	0.021	0.023	0.025	0.027	0.028	0.030	0.032	0.033	0.035	0.037
5	0.018	0.019	0.021	0.022	0.023	0.025	0.027	0.029	0.031	0.032	0.034	0.036	0.037	0.039
6	0.020	0.021	0.023	0.024	0.025	0.027	0.029	0.031	0.033	0.035	0.037	0.039	0.041	0.043
7	0.022	0.023	0.025	0.026	0.027	0.029	0.031	0.033	0.035	0.037	0.039	0.041	0.042	0.044
8	0.024	0.025	0.027	0.028	0.029	0.031	0.033	0.035	0.037	0.039	0.041	0.043	0.044	0.045
9	0.026	0.027	0.028	0.029	0.030	0.032	0.034	0.036	0.038	0.040	0.042	0.044	0.045	0.045
10	0.027	0.028	0.030	0.031	0.032	0.033	0.035	0.037	0.040	0.042	0.044	0.045	0.045	0.045
11	0.029	0.030	0.031	0.032	0.033	0.035	0.036	0.038	0.041	0.043	0.045	0.045	0.045	0.045
12	0.030	0.031	0.032	0.033	0.034	0.036	0.038	0.040	0.042	0.045	0.045	0.045	0.045	0.045

Machinery

than by taking a light finishing cut in the lathe, provided, of course, that a grinding machine of sufficient power is available.

Table I gives the allowance to be left on the diameters for grinding average work, but does not take into consideration special cases such as an extremely rough finish before grinding, hardened thin wall bushings that are liable to warp out of shape to a greater or less extent, or long shaft work that has been considerably sprung out of shape in hardening. Of course, long hardened shaft work, as a rule, requires straightening previous to grinding, but it is difficult to anticipate what will happen when the hardening scale is removed.

There are two distinct methods recommended for roughing out the work previous to grinding; one is to carefully turn the work to within from 0.010 to 0.015 inch of the finished size, and then finish by grinding; the other is to rough out the work quickly, taking light cuts (when the work is slender) with comparatively coarse feeds and high work-speeds, leaving a greater amount to remove by grinding; but as the tool "cuts a thread" on the work only the high points have to be removed by the grinding wheel over and above the amount left for grinding when the work is turned smooth. There are advantages in both methods, depending on the class of work being machined. Where the work is large in diameter in proportion to its length and will stand heavy lathe cuts, the latter method can be used to advantage. But where the work is light or small in diameter in proportion to its length, the first mentioned practice seems to be the safest one to follow. It is therefore evident that the amount to leave on the diameter for grinding is governed almost entirely by the character of the work and the other requirements mentioned.

Preparation of Work for Grinding

The preparation of soft work for grinding has been covered in the section dealing with the allowances for external cylindrical grinding, but much can be said regarding the preparation of work that must be hardened prior to grinding. Work that is hardened may be so bent or distorted as to require straightening, and there is always the chance that it may resume its crooked form after considerable time has been spent in grinding it. As a rule, this results from lack of care in preparing the steel previous to the machining operations. Steel, as it comes from the mill or forging machine, is likely to contain hidden strains that can only be released by reheating or annealing. If the annealing operation is carefully handled, it is possible to remove these strains and put the steel in such a condition that warping in hardening is reduced to a minimum.

If the piece of work to be machined is made from bar stock, it should be carefully centered and straightened as true as possible, previous to turning. This is necessary because the bar in its roughened condition is decarbonized on the surface, as well as for a slight distance below it, and this material, of course, must be removed in order to make the piece harden evenly. The straightening of the bar should not be done cold, as the bar will resume its original condition when heated. It is preferable to straighten the bar after it has been heated, and after this it can be roughed out in the lathe and then carefully annealed after the roughing cut has been taken. Should it come out crooked after the second annealing operation, it should be again straightened while hot and another cut taken. As a rule, this leaves it in a satisfactory condition for grinding.

In grinding shoulder shafts where the grinding machine is not provided with locating stops, it is generally advisable to neck the shaft at the shoulder previous to grinding, if a sharp corner is required on the work; then the operator does not need to be as careful in bringing his wheel in to the shoulder as he would if no necking were provided. When shoulder shafts are to be hardened previous to grinding, however, it is advisable where possible to have the corner rounded, having a liberal fillet to prevent warping and water cracks developing. Another point that should be observed in the grinding of shoulder shafts is to have the center holes all of the same depth in order that the stop for governing the location of the shoulders need not be changed for each shaft. It is necessary to give particular care to the centers in the work, especially when a large number of duplicate pieces are to be turned out.

When the shaft to be ground is provided with keyways, the best procedure is to first turn the shaft to the roughing size, then cut the necessary keyways and do the grinding last. Work cannot be finished satisfactorily in the lathe with a keyway cut in it, and if the grinding is done after the keyway is cut all objectionable burrs are removed and the work is finished without filing. In work that is hardened, the centers should be cleaned out and care taken to see that no burrs have been formed or that they have been otherwise deformed. It is impossible to get true cylindrical work on a poor center. A good lubricant for grinding machine centers is a mixture of powdered red lead (oxide of lead) and lard oil. When using this lubricant, if the lead dries out, the centers do not cut, but simply take on a high polish.

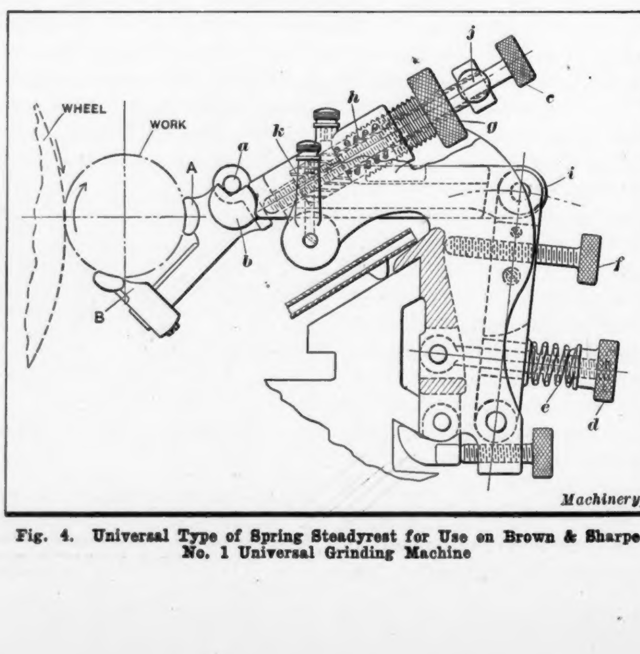


Fig. 4. Universal Type of Spring Steadyrest for Use on Brown & Sharpe No. 1 Universal Grinding Machine

Conditions Governing Width of Face of Grinding Wheels for External Cylindrical Grinding

The width of face to use for a grinding wheel is governed largely by the work to be ground and to some extent by the machine in which the operation is to be accomplished. In the first grinding machines, which were built for performing cylindrical grinding operations, narrow face wheels were used, because of the fact that the grinding machine was designed for finishing only and consequently was lightly constructed. Wide face wheels could not be used on the machine because of the liability of chatter from vibration, and wheels much wider than ½ inch were uncommon. In fact, a ½-inch wheel was at first the standard width for most work.

Following closely on the improvements made in the design of grinding machines, the width of wheel face was gradually increased for cylindrical grinding, until at the present time wheels as wide as 12 inches are used for some grinding operations. For traverse grinding, there are certain conditions that govern the width of the wheel. Referring to *A* and *B* in Fig. 2, a 1-inch face wheel is shown taking a roughing and finishing cut, respectively. When rough-grinding, a traverse feed is used that will enable the bulk of the material to be quickly removed. In theory, this traverse feed is supposed to be about equal to the width of the wheel, that is, the wheel would be advanced an amount equal to its width at each revolution of the work. In practice, however, this is very seldom used and a feed of from two-thirds to nearly the full width of the wheel per revolution of the work has been found to give the best results. In finish-grinding, the traverse feed of the wheel is somewhat reduced and is generally about one-third to one-quarter of the roughing feed.

There are two methods in use for rough- and finish-grinding cylindrical work, one of which is to increase the work speed for finishing and thereby decrease the traverse feed, and the other is to decrease the work speed as well as the traverse feed. Both methods are used to advantage in grinding practice, and the one to be employed depends on several conditions. Take a certain job upon which a comparatively soft free-cutting wheel is used. For rough-grinding, the work speed would be about 25 feet per minute, and if this same wheel were used for finish-grinding, it would be necessary to reduce the work speed about 25 per cent to get the desired finish. Should a harder and more compact wheel be used for finishing, the speed would be increased over that used for roughing. In modern grinding practice, when rough-grinding it is generally advisable to use a fairly coarse wheel of a soft enough grade to cut freely, and a comparatively slow work speed in conjunction with a coarse side feed of the wheel or work. This method can be used to the best advantage on machines that are heavily constructed and provided with sufficient driving power to enable these broad cuts to be taken without excessive vibration. With a light grinding machine, however, this coarse feed is not advisable, owing to the lack of rigidity and the low driving power, so that the question as to whether a high or low work speed for finishing is better is dependent in most cases upon the wheel used and to a certain extent upon the machine that carries it. As a general rule, however, the harder the bond and finer the grain of the wheel used, the higher should be the work speed.

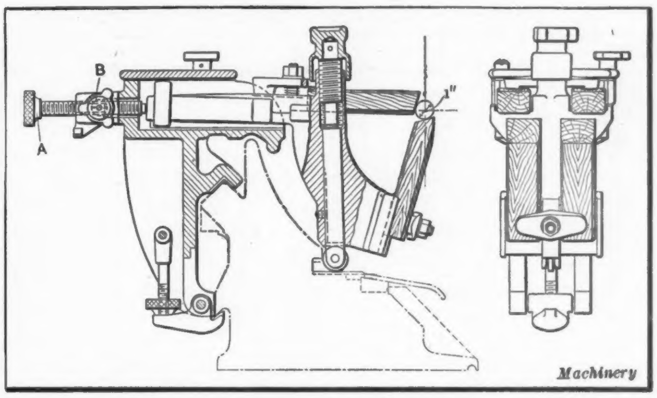


Fig. 6. Solid Type of Steadyrest adapted to 14-, 18- and 20-inch Norton Plain Grinding Machines

Two of the chief requirements are production and accuracy. In some cases one is sacrificed for the other, whereas in others both may be necessary. Usually, however, production is the factor that is most sought; consequently anything that tends to increase production is of value. One of the factors that assists in increasing production is increasing the width of the wheel face. This, as is shown by *C* in Fig. 2, enables greater traverse feeds to be taken, and where the machine is of sufficient power and rigidity, the wide face wheel is capable of greatly increasing production over a narrower face wheel. In other words, a greater number of pieces could be turned out by the wheel shown at *C* than by that at *A* because of the possibility of increasing the traverse feed per revolution of the work. The most advanced practice, therefore, is to use a wide face wheel varying in width from about 1½ to 4 inches (for traverse grinding) and a comparatively coarse feed and slow work speed. In this way, the excess material on the diameter of the work can be most economically removed. Of course in using a wide face wheel it is necessary that the work be properly supported, and for this reason a liberal use of steadyrests is advisable. In many cases, the greater the number of back-rests used, the greater will be the accuracy and production.

There are cases where the advantage of a wide face wheel is questionable. Take, for instance, a small slender shaft ¼ inch diameter and 12 inches long (see *D* Fig. 2) which has been hardened. On hardened work a harder bond wheel is used than for soft work, and consequently there is a slightly greater pressure on the work when grinding it. For this reason it is sometimes advisable to cut down the width of the face of the wheel in order to reduce the wheel pressure. The practice with some manufacturers is to use an elastic wheel about ½ inch face for both roughing and finishing cuts, using a softer bond wheel for roughing than for finishing. In addition to this, the work must also be rigidly supported by means of steadyrests, and light cuts with rough traverse feeds and high work speeds are used. There are cases, however, when a slender shaft can be ground with a comparatively wide face wheel, but this is recommended more for the grinding of soft work than for hardened work. Practice differs to some extent in the grinding of small slender shafts, depending on the condition of the work and the finish desired. On machine tool work where a shaft is to be held to close limits, great care is exercised both in roughing and finishing, in order to get the desired results.

In "straight-in" grinding still another condition is presented which governs the width of the face of the wheel, as shown at *E* in Fig. 2. Here the wheel must be of a width slightly greater than the length of the portion to be ground, because it is fed straight in on the work without any lateral traverse. The usual practice is to have the

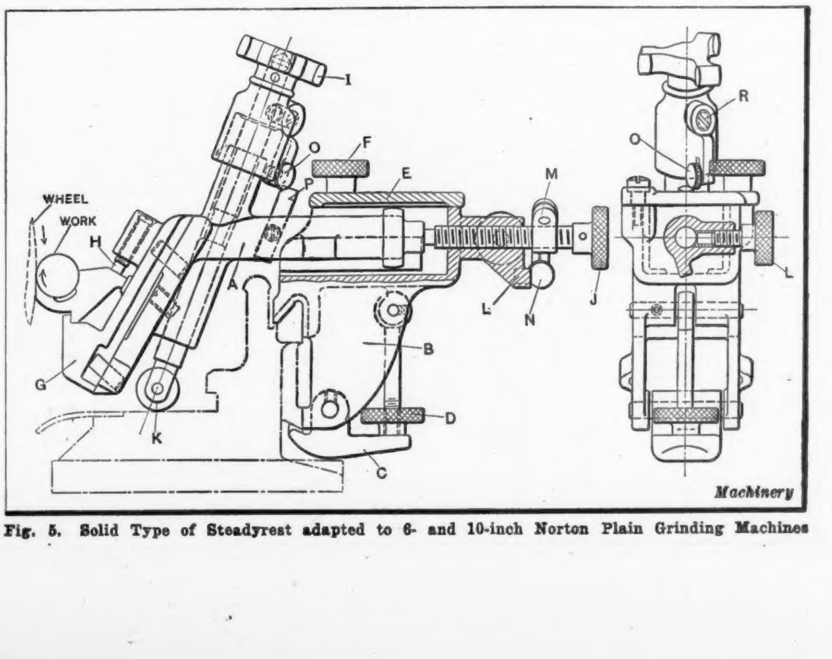


Fig. 5. Solid Type of Steadyrest adapted to 6- and 10-inch Norton Plain Grinding Machines

TABLE II. GRINDING WHEEL SPEEDS

Diam. of Wheel in Inches	Surface Speed of Grinding Wheel in Feet per Minute								
	4000	4500	5000	5500	6000	6500	7000	7500	8000
	R. P. M. of Grinding Wheel								
4	3820	4297	4775	5252	5730	6207	6684	7162	7639
5	3056	3438	3820	4202	4584	4966	5348	5730	6112
6	2546	2865	3183	3501	3820	4138	4456	4775	5093
7	2183	2455	2728	3001	3274	3547	3820	4092	4365
8	1910	2148	2387	2626	2865	3103	3342	3581	3820
10	1528	1719	1910	2101	2292	2483	2674	2865	3056
12	1273	1432	1592	1751	1910	2069	2228	2387	2546
14	1091	1227	1364	1500	1637	1773	1910	2046	2183
16	955	1074	1194	1313	1432	1551	1671	1790	1910
18	849	955	1061	1167	1273	1379	1485	1592	1698
20	764	859	955	1050	1146	1241	1337	1432	1528
22	694	781	868	955	1042	1128	1215	1302	1389
24	637	716	796	875	955	1034	1114	1194	1273
26	587	661	734	808	881	955	1028	1101	1175
28	546	614	683	751	819	887	955	1022	1091
30	509	573	637	701	764	827	891	955	1019
32	477	537	597	656	716	775	835	895	955
34	449	505	561	617	674	730	786	842	898
36	424	477	531	584	637	690	743	796	849

Machinery

wheel anywhere from ¼ to 1 inch wider than that portion of the work covered by it.

In grinding the throws of crankshafts, as shown at *F* in Fig. 2, the width of face of the wheel is governed by the distance between the cheeks of the crank. In this case the wheel has to be held down to fairly accurate dimensions as regards width, and usually is slightly less in width than the distance between the cheeks, the sides of the cheeks being finished previous to grinding in an engine lathe. There are, of course, other conditions met with in cylindrical grinding that call for specified widths of wheel faces, but those given in the foregoing cover general practice.

Wheel and Work Speeds for External Cylindrical Grinding

The recommended peripheral speeds for wheels for external cylindrical grinding vary from 5000 to 7000 feet surface speed per minute. Wheels softer than grade K should not be operated at a speed above 6000 feet, whereas hard bond wheels can be operated up to 8000 feet, although a speed as high as this is not recommended for general work. Wheels made from corundum, alundum or like abrasives are generally operated at 6000 feet surface speed, whereas wheels made from carbolite, crystolon, carborundum, etc., are generally operated at 5500 feet surface speed.

The speed of the wheel, however, is governed largely by the character of the work and the machine on which it is being used. For instance, other conditions being equal, a grinding machine of massive construction can successfully use soft wheels and run at lower speeds than a grinding machine of a lighter type. The greater mass of the heavy machine reduces vibration and makes the soft wheel work efficiently, where a harder wheel and a higher speed would be necessary to get good results on a lighter machine. Table II gives the corresponding revolutions per minute for grinding wheels from 4 to 36 inches in diameter when operated at peripheral speeds of 4000 to 8000 feet per minute.

The efficiency of a grinding wheel is dependent upon the relative speeds of the wheel and work. In order to have some constant to work from, it is advisable to have the wheel speed fixed and the work speed varied until satisfactory results are obtained, assuming that the proper wheel for the work has been selected. After deciding upon the wheel and wheel speeds, the next factors to take into consideration are the relations between the work speed and side feed of the wheel or work. These factors, in turn, have a direct bearing upon the wheel wear. For instance: the higher the work speed—other factors remaining the same—the greater the wheel wear; the greater the depth of cut the greater the wheel wear; and the more the vibration the greater the wear on the wheel.

At the present stage of the grinding art there are in use two general conditions or groups of combinations of wheel speeds, work speeds, feeds, etc. The first group includes soft wide wheels, slow wheel and work speeds, and greater side traverse with a comparatively shallow depth of cut, whereas, the second includes narrow and hard wheels, high work and wheel speeds and slow side traverse or fine feeds. The depth of cut bears an inverse ratio in either case to the traverse speed and can be increased without any marked change of results, provided the side traverse is correspondingly decreased. The conditions just mentioned refer more directly to roughing out, and obtaining a commercial finish. To obtain a fine finish, most authorities agree that a higher work speed and finer traverse feed is desirable, together with the use of a finer grain, harder bond wheel.

The question of work speeds is therefore a broad one. In the first combination of conditions previously mentioned, the

TABLE III. WORK SPEEDS FOR CYLINDRICAL GRINDING

Diameter of Work in Inches	Surface Speed of Work in Feet per Minute																	
	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	90	100
	R. P. M. of Work																	
1/4	76.4	152.8	229.0	305.0	382.0	458.0	535.0	611.0	688.0	764.0	851.0	917.0	994.0	1070.0	1147.0	1222.0	1376.0	1528.0
3/8	50.9	101.8	153.0	204.0	255.0	306.0	357.0	408.0	458.0	509.0	560.0	611.0	662.0	713.0	764.0	815.0	916.0	1018.0
1/2	38.2	76.4	114.0	153.0	191.0	229.0	268.0	306.0	344.0	382.0	420.0	459.0	497.0	535.0	573.0	611.0	688.0	764.0
5/8	30.6	61.2	92.0	122.0	153.0	184.0	214.0	245.0	276.0	306.0	337.0	367.0	398.0	428.0	459.0	489.0	552.0	612.0
3/4	25.4	50.8	76.5	101.0	127.0	153.0	178.0	203.0	229.0	254.0	279.0	306.0	330.0	357.0	381.0	408.0	458.0	508.0
7/8	21.9	43.8	65.5	87.5	109.0	131.0	153.0	175.0	196.0	219.0	241.0	262.0	285.0	306.0	329.0	349.0	392.0	438.0
1	19.1	38.2	57.5	76.5	95.5	115.0	134.0	153.0	172.0	191.0	210.0	229.0	258.0	267.0	287.0	306.0	344.0	382.0
1 1/8	17.0	34.0	51.0	68.0	85.0	102.0	119.0	136.0	153.0	170.0	187.0	204.0	221.0	238.0	255.0	272.0	306.0	340.0
1 1/4	15.3	30.6	45.9	61.5	76.3	91.8	107.0	123.0	137.0	153.0	168.0	183.0	199.0	214.0	230.0	245.0	274.0	306.0
1 1/2	12.7	25.4	38.1	51.0	63.7	76.3	89.2	102.0	115.0	127.0	140.0	153.0	165.0	178.0	191.0	204.0	230.0	254.0
1 3/4	10.9	21.8	32.7	43.6	54.5	65.5	76.4	87.3	98.2	109.0	120.0	131.0	142.0	153.0	164.0	175.0	196.0	218.0
2	9.5	19.1	28.6	38.2	47.8	57.3	66.9	76.4	86.0	95.5	105.0	115.0	124.0	134.0	143.0	153.0	172.0	191.0
2 1/4	8.5	17.0	25.5	34.0	42.2	51.0	59.4	68.0	76.2	85.5	93.5	102.0	111.0	119.0	128.0	136.0	153.0	170.0
2 1/2	7.6	15.3	22.9	30.6	38.2	45.8	53.5	61.2	68.8	76.3	84.2	91.7	99.5	107.0	114.0	122.0	138.0	153.0
2 3/4	6.9	13.9	20.8	27.8	37.4	41.7	48.6	55.6	62.5	69.5	76.5	83.4	90.4	97.2	104.0	111.0	125.0	139.0
3	6.3	12.7	19.1	25.5	31.8	38.2	44.6	51.0	57.3	63.7	69.9	76.4	82.6	89.1	95.3	102.0	114.0	127.0
3 1/2	5.4	10.9	16.3	21.8	27.3	32.7	38.2	43.6	49.1	54.5	60.0	65.5	70.8	76.4	81.8	87.4	98.1	109.0
4	4.8	9.5	14.3	19.1	23.9	28.7	33.4	38.2	43.0	47.8	52.6	57.3	62.1	66.9	71.7	76.4	86.0	95.6
4 1/2	4.2	8.5	12.7	17.0	21.2	25.4	29.6	34.0	38.2	42.4	46.6	51.0	55.1	59.4	63.6	67.9	76.3	84.8
5	3.8	7.6	11.4	15.8	19.1	22.9	26.7	30.6	34.4	38.2	42.0	45.9	49.7	53.5	57.3	61.1	68.8	76.4
5 1/2	3.4	6.9	10.4	13.9	17.4	20.8	24.3	27.8	31.3	34.4	38.2	41.7	45.1	48.6	52.0	55.6	62.5	69.4
6	3.2	6.3	9.5	12.7	15.9	19.1	22.3	25.5	28.7	31.8	35.0	38.2	41.3	44.6	47.7	51.0	57.2	63.6
7	2.7	5.4	8.2	10.9	13.6	16.4	19.1	21.8	24.6	27.3	30.0	32.7	35.5	38.2	41.0	43.7	49.1	54.6
8	2.4	4.8	7.6	9.5	11.9	14.3	16.7	19.1	21.1	23.9	26.3	28.7	31.0	33.4	35.9	38.2	43.0	47.8
10	1.9	3.8	5.7	7.6	9.5	11.4	13.3	15.3	17.2	19.1	21.0	22.9	24.8	26.7	28.6	30.5	34.4	38.2
12	1.6	3.2	4.7	6.3	7.9	9.5	11.1	12.7	14.3	15.9	17.5	19.1	20.6	22.3	23.8	25.5	28.6	31.8

Machinery

work speed is taken at from 5 to 20 feet surface speed per minute, for roughing out, and 25 to 40 feet surface speed for finishing, and a traverse of from two-thirds up to the full width of the wheel per revolution of the work.

The second combination calls for a work speed of from 25 to 60 feet per minute for roughing and 60 to 100 feet for finishing, with a side traverse of from one-quarter to one-half the width of the wheel per revolution of the work. For average work, the Brown & Sharpe Mfg. Co. recommends a speed for roughing of from 25 to 65 feet and from 10 to 20 feet higher in all cases for finishing. Table III gives the surface speeds of work for various diameters ranging from 5 to 100 feet surface speed per minute.

The character of the material being ground also has a considerable bearing upon the speed of the work, and assuming that a satisfactory wheel for the work in each case has been selected, the surface speed for the work can then be more easily determined. The work speeds given in Table IV are taken from general practice, and do not cover special conditions, or take into consideration the diameter of the work, which also is a deciding factor in the selection of the proper work speed to use. The depth of cut per traverse of the wheel or work, as has been previously mentioned, varies from 0.0005 to 0.003 inch. For roughing out, the depth of cut (on the radius of the work) varies from 0.0015 to 0.003 inch, and for finishing, from 0.0005 to 0.001 inch.

Methods of Preventing Chatter

Chattering is generally attributed chiefly to vibration. It was not at first recognized that chatter marks were caused by the vibration of the work itself, but the fault was laid to vibration of the machine and the foundation upon which it was placed. Considerable time and money was spent on foundations before the true cause of chatter was ascertained. It is now a comparatively well-known fact that practically all work that is ground will vibrate to a greater or less extent under the cut of the wheel, regardless of the machine in which it is ground. Chatter is usually caused by the work not being properly supported and by the use of incorrect work speeds. By selecting the correct work speed and properly supporting the work, it is possible to grind cylindrical work round and smooth and produce an accurate surface.

Chatter in the work is sometimes attributed to imperfect gearing in the machine, where the machine is of the gear-driven type. As a rule, however, it will be found that the gearing is correct and the marks are caused by the vibration of the work. It is probable in some cases that the driving dog sets up vibration owing to the fact that there is torsion in the dog when a heavy cut is taken and when the work is not properly supported. Chatter marks usually take the form of small flats that appear on the surface of the work, and it is sometimes possible to locate the trouble from the appearance of these flats. They also assume in some cases a spiral form of coarse pitch, which generally indicates that the wheel is untrue or not of homogeneous structure. When they are of a fine pitch in spiral form, the cause is generally vibration of the wheel spindle, which may be either too weak or loose in its bearings. Driving belts that are of unequal thickness may vibrate the wheel spindle to such an extent as to cause chatter of the work. Another method to obviate chatter on large work is to provide the work with larger center holes so as to have as large a support as practicable on the centers. Chattering can sometimes be avoided by giving particular attention to the relation of the wheel and the work speed, by having these speeds so adjusted that the wheel will not have a tendency to glaze but will at all times be free cutting.

Chatter marks are likely to develop in the grinding of crankshafts or other work that is of irregular shape or eccentric at various portions along its length. This is due to the eccentricity of the revolving mass, throwing the work out of balance and causing vibration. One way to avoid this is to reduce the speed of the work, but the most satisfactory way is to balance the work properly so as to reduce the vibration to a minimum. Assuming that the grinding machine is in perfect running condition, and that the wheel is perfectly balanced and properly dressed, if chatter marks develop it is a sure indication that the work is improperly supported. Therefore, one of the best ways of overcoming chatter is to support the work properly by means of steadyrests. There is practically no job of cylindrical grinding of any length where a steadyrest is not an advantage, no matter how heavy the piece of work or of what shape or length. A steadyrest is always an advantage and will increase production if used with a correct speed of wheel and work. The combination of proper steadyrest and slow work speed is one of the best ways of overcoming chatter and securing a good finish on accurate work.

Different Types of Steadyrests

Steadyrests properly applied will, in most cases, obviate chatter marks on the work. There are some classes of work, of course, for which a steadyrest is of very little advantage, but on long slender work a steadyrest is necessary to reduce vibration and enable accurate work to be turned out rapidly. The type of steadyrest to use depends largely on the character of the work, type of machine, and to a certain extent on personal preference. Most authorities on this subject, however, advocate the use of spring steadyrests for light slender

TABLE IV. WORK SPEEDS FOR ROUGH- AND FINISH-GRINDING VARIOUS MATERIALS

Work speeds based on 6000 feet surface speed for Alundum, Aloxite and Corundum wheels, and 5500 feet for Carbolite, Carborundum and Crystolon Wheels

Material	Abrasive	Process of Manufacture	Grain	Grade	Surface Speed of Work in Feet per Minute	
					Roughing	Finishing
Aluminum (Cast)	Carbolite, Carborundum or Crystolon	Elastic	36 to 40	2 E to 2½ E 2 4	60 to 70	60 to 70
Brass or Bronze (Cast)	Corundum, Carborundum or Crystolon	Vitrified	24 to 30	M to N L to M P	60 to 70	60 to 70
Iron (Cast)	Carbolite, Carborundum or Crystolon	Vitrified	40 to 46	K to M L to N L to M	50 to 55	50 to 55
Steel-Alloy, Heat-treated	No. 38 Alundum No. 58 Corundum Aloxite	Vitrified	24 Comb. 40	L J	20 to 25	30 to 40
Steel 0.20 to 0.50 Per Cent Carbon (Soft)	No. 38 Alundum No. 58 Corundum Aloxite	Vitrified	24 to 36 Comb. 36	L to M M to O	25 to 30	40 to 45
Steel 0.20 to 0.50 Per Cent Carbon (Hardened)	Alundum, Corundum or Aloxite	Vitrified	46 36	K P	30 to 35	50 to 55

Machinery

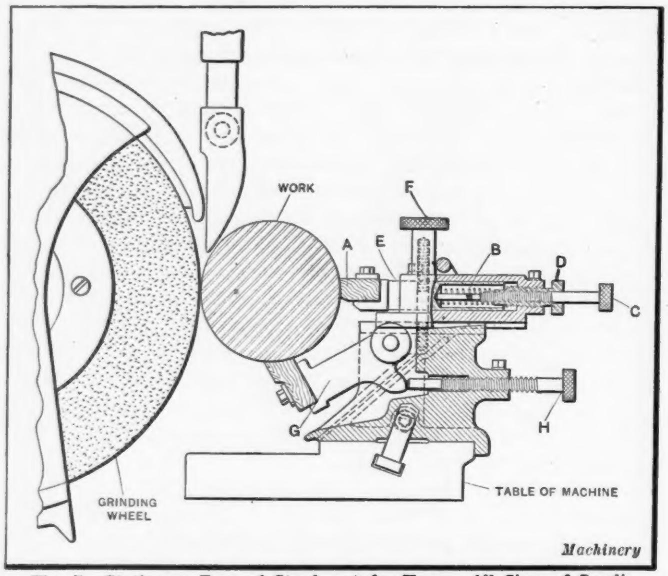


Fig. 7. Stationary Type of Steadyrest for Use on All Sizes of Landis Plain and Universal Grinding Machines

work, and rigid rests for heavy work. Practically all spring steadyrests, however, are capable of being locked, so that they are rigid enough in most cases to be applied to both heavy and light work.

Spring Steadyrests of Plain and Universal Types

One of the simplest types of steadyrests is shown in Fig. 3. This is called a plain steadyrest, and is only used where the work can be more conveniently ground with a slight additional support. It is not universally adjustable and consequently its range is limited. In steadyrests of this kind, shoes of both metal and wood are used; for hardened work, as a rule, shoes made from bronze are found to give the best results. The shoes are shaped to suit the work, and usually, instead of having a bevel as shown, the surface is curved to fit the diameter of the work being ground. When only a few pieces of one size are being turned out, however, the shoes for steadyrests of this type are generally made from wood because they can be more easily made and fitted than metal shoes.

A steadyrest of the universal type adapted for use on the No. 1 Brown & Sharpe universal grinding machine is shown in Fig. 4. This steadyrest is universal in all its movements, and capable of very delicate adjustment. The solid shoe used in this rest is generally made of bronze and a different size is required for each variation in diameter of the work. This type of rest is particularly adapted to work requiring a high degree of accuracy, and especially for shafts that are keyseated or under 1 inch in diameter. Its use is recommended where a large volume of work of one diameter is to be done. The same steadyrest, however, with adjustable shoes can be used for work on which a few pieces only are required.

The method of operating this steadyrest is as follows: First, select a shoe of the size of the work being ground, and hook the trunnion *a* in the V-support *b*. Then turn screw *c* back far enough to allow the shoe to clear the work, and loosen nut *d* to relieve the pressure on spring *e*. Then turn back screw *f*. Next turn screw *g* forward until a light pressure is given to spring *h*.

Screw *c* should now be turned forward and if spring *e* is wholly relieved and screw *f* is back far enough, the shoe will come in contact with the work at both points *A* and *B*. A slight pressure should now be exerted on trunnion *i* to hold the shoe in contact with the work, and screw *f* should be carefully tightened, noting the slightest touch of the end of the screw against the stop so that none of the parts will be moved. With this screw still in contact with the stop, the shoe should bear equally at both points *A* and *B*. Nut *d* should then be tightened to increase the pressure on spring *e*. The combined pressure on springs *e* and *h* should be just sufficient to resist the pressure of the wheel when taking the last cut on the work and to prevent vibration of the work under any cut that it may be desired to take. After the proper adjustments have been made, clamping screw *j* should be tightened to prevent screw *c* from loosening.

The next step is to grind a trial piece of work; at this time screw *c* is moved to maintain the contact of the shoe with the work, and screw *f* is adjusted to preserve the relative diameters at the various points. As the work approaches the finished size, it should be measured where the different steadyrests contact with it after each cut. After the trial piece is finished with the diameters alike at all points, the shoe should bear equally at points *A* and *B* and the sliding nut *k* should rest against the shoulder. The parts should now be left in this relation and another piece of work ground, adjusting the screw *c* only as the shoe wears and screw *f* for slight changes of the diameter. The effect of this adjustment should be noted on the work by the sparks from the wheel.

With the various screws properly adjusted, the springs of this steadyrest cannot push the work beyond the required size. When the work is finished to size, nut *k* and screw *f* should rest against the shoulder and stop, respectively, so that further pressure of the springs is impossible. The shoe and wheel will then be left in the proper position for sizing duplicate pieces. It is necessary, however, to get the relative pressures of springs *e* and *h* correct. When unground work is placed on the centers of the machine and in the shoe bearings, the nut *k* and screw *f* will be forced away from the shoulder and stop, thus compressing the springs *e* and *h*. Should the shoe bear unequally at points *A* and *B*, tighten screw *d* to increase the pressure at *A*, and screw *g* to increase the pressure at *B*. The combined pressure of springs *e* and *h*, however, should not be greater than is necessary to support the work, as long, slender work, although of uniform diameter, may not be straight when released from the shoes unless some allowance is made for the elasticity of the material. When adjustable bronze shoes are used to support pieces of various diameters, first loosen the screw which clamps the lower bearing shoe, and adjust it until the work bears centrally on both shoe surfaces, then retighten the set-screw.

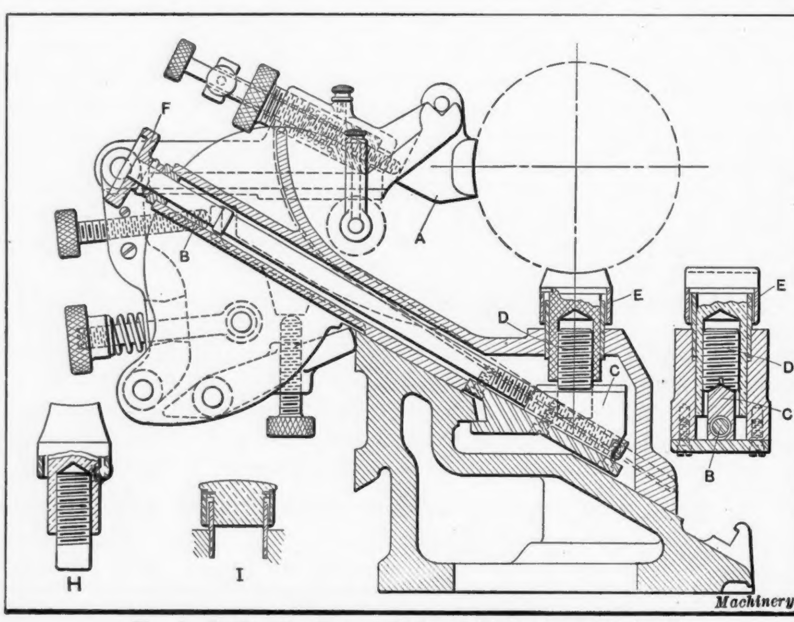


Fig. 8. Combination Type of Plain and Rigid Steadyrest adapted to Brown & Sharpe Plain Grinding Machines

Solid Type of Steadyrests

The steadyrest shown in Fig. 5 is known as the solid type of steadyrest and is used wherever possible on Norton 6-inch and 10-inch machines. It is particularly adapted for carrying hardened and ground work-shoes and is used especially where exact duplication of work is required, say to limits of 0.0005 inch. For the 6-inch machine, this steadyrest has a range of from ¼ to 2½ inches in diameter, and for the 10-inch machine from ¼ to 4 inches in diameter. Hardened work-shoes are

used only when the work is standard, that is, where a number of pieces of the same size are being made, but for jobbing work wooden shoes are used in place of the hardened ones.

In applying the solid type of steadyrest, the shoe should be brought up firmly against the work while in the rough, whether the work be out of round or not. Grinding machine operators, as a rule, hesitate to do this because they see the shaft sprung out of line and wabbling back and forth. The irregularity of contour, however, which causes displacement, does not appreciably affect the final accuracy of the ground part. The reason for this is that as the roughness is removed the lateral displacement becomes less and less and finally disappears altogether when the work is true. Then the steadyrests that support the work longitudinally may be adjusted for the finish-grinding.

The method of applying and operating the steadyrest shown in Fig. 5 is as follows: The adjustable support *A* can be raised, lowered or moved longitudinally, and the body *B* is quickly clamped on the machine with clamps *C* and thumb-nut *D*. The cover *E* is held in place by a thumb-screw *F*, and when this screw is released can be swung on a pivot to permit the removal of the adjustable support *A*. The work-shoe is hardened and ground to size, this shoe being quickly put in place or removed from the holder *G* by means of a screw *H*. It has a bearing in the holder on three points, thus insuring rigidity.

The vertical adjustment of the shoe is secured through knob *I* and the horizontal or back-and-forth adjustment through screw *J*. The roll *K* moves freely on the resting surface of the work-table and allows free horizontal motion of work that is not true and straight before grinding. The knob *L* is used to clamp the screw *J* when necessary. The adjustable stop *M* is threaded onto the screw *J* and allows free motion until the correct size is obtained on the first of a number of duplicate pieces that are to be ground. Then stop *M* is made fast to the screw *J* by clamping screw *N*. The screw *J* can then be turned back to allow an unground piece of work to be placed on the centers and ground. This screw is then adjusted from time to time as the grinding proceeds until the stop-screw is reached, which limits further motion of the work supports and gives accurate duplication of work; the stop-screw (not shown) in stop *M* also allows delicate adjustment for the exact size of work to be obtained. Stop-screw *O* serves the same purpose for the vertical adjustment of the rest, coming in contact with stop *P*. The clamping screw *R* fastens the stop firmly to the shoulder on knob *I*. Wooden work-shoes can be used in this steadyrest instead of hardened shoes where only a small number of pieces are to be ground.

The steadyrest shown in Fig. 6 is also of the solid type, and is used on Norton 14-, 18-, and 20-inch machines, each rest being supplied with a set of four hard wooden blocks, two on the horizontal support and two on the angular or vertical supports. This steadyrest is fastened to the machine in the same manner as that shown in Fig. 5, but the method of adjusting the supporting shoes is somewhat different. In this case the horizontal supports are not adjustable up or down from the center of the work, but of course can be adjusted back and forth, and are held in place by means of a toe clamp. The vertical shoes are adjusted in a similar manner to that shown in Fig. 5, and are controlled by the screw *A* provided with a locking nut *B*. The angle on the lower shoe is changed for different diameters of work, as will be described in connection with the diagram illustrating different types of work-shoes. This type of steadyrest, as will be described later, is also provided with shoes made from different materials. For large-diameter work, the lower shoes are made of cast iron instead of wood. This type of steadyrest is never used to support work of a long slender nature, but is used chiefly for large-diameter work, the wooden shoes being used for work up to about 4 inches diameter and the iron shoes for work of larger diameter than this, up to the full capacity of the machine.

The steadyrest shown in Fig. 7 is also of the stationary type, but is constructed somewhat differently from those just described. This steadyrest is adapted to the Landis plain and universal grinding machines, and the two work-supporting shoes are operated independently. The horizontal shoe is carried in a plunger that is kept outward by means of a spring *B* and is backed up by an adjusting screw *C*. The tension of the spring is adjusted by means of screw *D*. Plunger *E* can be clamped rigidly in any position by means of the clamping screw *F*. The lower work-shoe support *G* is actuated by the adjusting screw *H*, which is operated to keep the work-shoe in contact with the work as the diameter of the latter is reduced by the grinding wheel. Where hardened work or large quantities of any particular part are being ground, the wooden blocks can be replaced by bronze or hardened steel blocks, depending on the number of pieces to be turned out.

Combination Plain and Rigid Steadyrest

Fig. 8 shows a combination plain and rigid steadyrest that is applied to the Brown & Sharpe plain grinding machines. This rest is especially adapted for supporting large heavy work. The upper member of the steadyrest is similar to the one shown in Fig. 4, and the horizontal shoe *A* is operated in a similar manner. The lower steadyrest shoe is operated by means of plunger screw *B*, in the manner shown more clearly in the sectional view to the right. Here it will be seen that screw *B* draws a tapered block *C* back and forth in a slot in screw *D*. Screw *D* also serves as a pivot upon which adjustable shoe *E* can be used for elevating above the range obtained with the adjustable wedge. As the diameter of the work is reduced, therefore, knob *F* is adjusted, the other support being taken care of by the spring or self-adjusting member of the steadyrest. Various types of shoes are provided with this steadyrest as shown at *H* and *I*. *H* shows one for comparatively small-diameter work, whereas *I* shows one adapted to large-diameter work.

Adjustable Steadyrest working on the Wedge Principle

The steadyrest shown in Fig. 9 which is adapted to the Pratt & Whitney plain grinding machine is of such construction that the work-shoe automatically follows up and supports the work as the grinding progresses. The proper relation between the work and shoe is maintained by the downward movement of the lever *A*, which raises the shoe-holder *D* and the shoe as the work is reduced in diameter. This downward movement of lever *A* causes roll *B* to advance along its path, which has sufficient inclination to permit the back pressure being taken by the roll without slipping. The pressure is governed by adjustable weights on lever *A*, which are held in place by thumb-screws. When the work has been reduced to the required diameter, the shoe is withdrawn by returning roll *B* to its original position and raising lever *A* to its upper position, where it is held by catch *C*. Both radial and vertical adjustments are provided by means of adjusting screws, and the bracket can be removed from the table by a slight inward pressure on the eccentric binding clamp.

Follow Type of Steadyrest

Fig. 10 shows a follow type of steadyrest which is applied

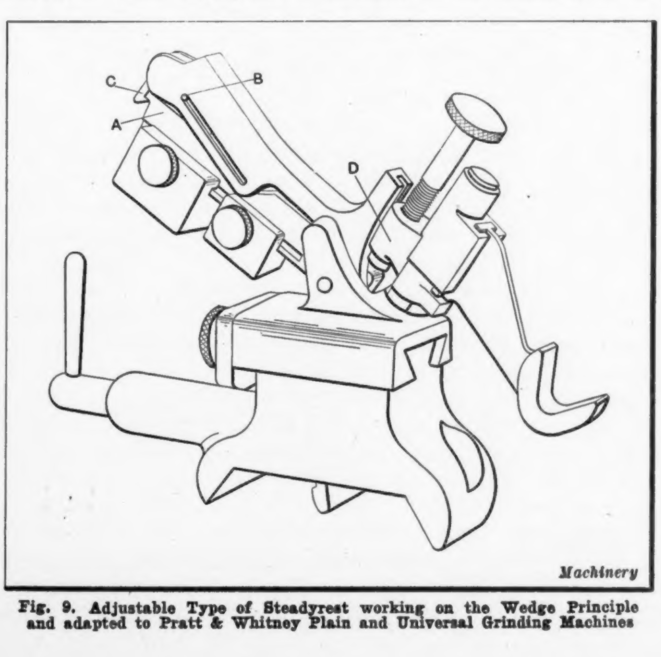


Fig. 9. Adjustable Type of Steadyrest working on the Wedge Principle and adapted to Pratt & Whitney Plain and Universal Grinding Machines

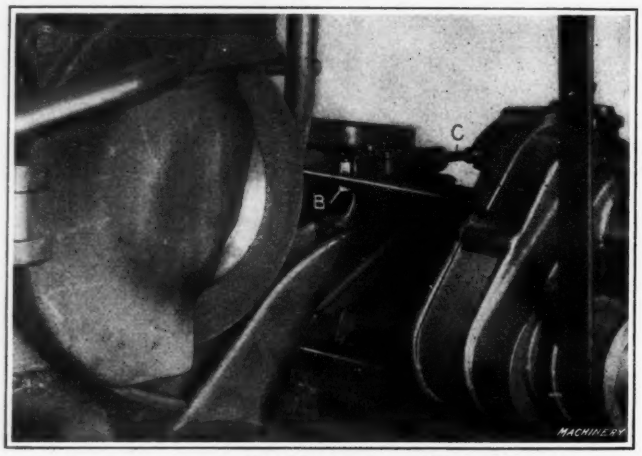


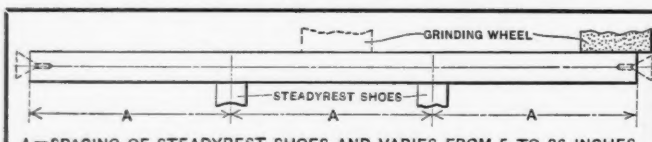
Fig. 10. Follow Type of Rigid Steadyrest applied to Brown & Sharpe No. 10 Plain Grinding Machine

to the No. 10 Brown & Sharpe plain grinding machine. This rest remains directly in front of the grinding wheel, and supports the work as it is traversed past it. The bracket *A* in which the steadyrest shoe is supported is clamped to the wheel-slide and consequently has no movement relative to the work. The work-shoe *B* is generally made with a concave or vee face to suit the work, and the pressure of the shoe is directed to hold the work up to the wheel. This shoe is adjustable by means of screw *C* and is not spring-controlled. This type of steadyrest can be used to advantage for grinding long slender work, which must be brought to accurate dimensions.

Use and Location of Steadyrests

Practically all grinding authorities agree on the fact that the more steadyrests used the greater will be the production; also that there is rarely a case where the work can be ground to good advantage without the use of steadyrests. While this may be true as a general statement, grinding machine operators have not always followed the advice given, and only use steadyrests where they cannot possibly do without them. On work, say, which is 1½ inch in diameter by 4 inches long, it is doubtful if much would be gained by using a steadyrest, but where the work is say 3 feet long and 1 inch in diameter, it would be practically impossible to grind it straight and true without a steadyrest. Therefore the number of steadyrests to use depends largely on the diameter and length of the work. No hard and fast rule can be laid down for the number of steadyrests to be used on any particular part, because this depends largely on the shape, diameter and length of the work. Usually, however, steadyrests are located about 6 inches apart on work about 1 inch in diameter; the greater the diameter, the less the number of steadyrests and the greater the distances between them. Table V gives the spacing of steadyrests as recommended by the Landis Tool Co. for work varying in diameter from ½ to 12 inches and in length from 6 inches to 84 inches.

TABLE V. MINIMUM NUMBER OF STEADYRESTS REQUIRED FOR SUPPORTING PLAIN CYLINDRICAL WORK



A=SPACING OF STEADYREST SHOES AND VARIES FROM 5 TO 36 INCHES DEPENDING UPON THE DIAMETER OF THE WORK

Diameter of Work in Inches	Length of Work in Inches										
	6	12	18	24	30	36	42	48	60	72	84
	Number of Steadyrests										
½ to 11/16	1	2	3	4	5	7	8	..	..	..	..
¾ to 15/16	..	1	2	3	4	5	6	7	..	..	..
1 to 1⅜	..	1	2	2	3	4	5	5	7	..	..
1½ to 1⅞	..	1	1	2	2	3	4	4	5	7	..
2 to 2⅜	..	..	1	1	2	2	3	3	4	5	6
2½ to 2⅞	..	..	1	1	2	2	2	3	4	5	5
3 to 3⅞	..	..	1	1	1	2	2	2	3	4	5
4 to 4⅞	..	..	..	1	1	1	2	2	3	3	4
5 to 5⅞	..	..	..	1	1	1	1	2	2	3	3
6 to 7⅞	..	..	..	..	1	1	1	1	2	2	3
8 to 9⅞	..	..	..	..	..	1	1	1	1	2	2
10 to 12	..	..	..	..	..	..	1	1	1	1	2

Machinery

This table applies particularly to straight plain work. In the case of such pieces as armature shafts and similar work, where there are a number of sizes or diameters on the same piece, the piece is more rigid in the center on account of having a larger diameter at this point, so that the spacing of the steadyrests is dependent largely on the judgment of the operator. For instance, in case the piece should be of a certain length and certain size at the ends and much larger in the center, it might be sufficiently rigid to make the use of a steadyrest unnecessary. If, on the other hand, the work was of the same diameter along its entire length, it probably would be necessary to use one or several steadyrests in order to support it rigidly. In general, the number of steadyrests to be used should be governed largely by the smallest diameter of the work being ground, especially if the smallest diameter is located next to either the headstock or tailstock centers. Of course the point on which the grinding is being done also has a considerable bearing on the position and number of steadyrests used. In the following examples of plain cylindrical traverse grinding, the steadyrests used on each job have been indicated, and from this it will be possible to draw conclusions as to where steadyrests should be used and the number required for various classes of work.

Fig. 11 shows a good application of steadyrests and indicates just about how these should be located in relation to

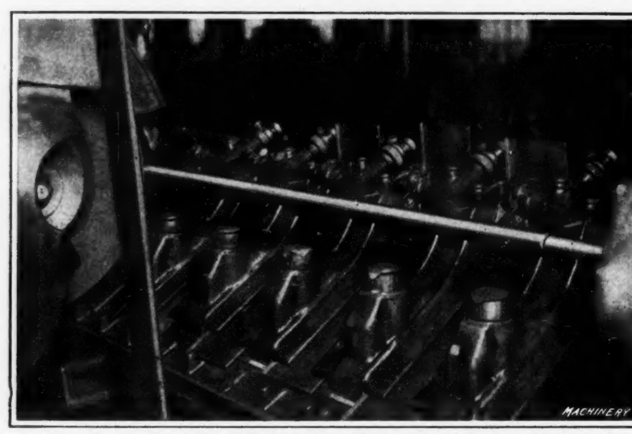


Fig. 11. Application of Brown & Sharpe Combination Plain and Rigid Type of Steadyrest

the work. This particular shaft is smaller on both ends than it is in the center. It is 1 inch diameter at the center, ¾ inch diameter at each end, and 48 9/16 inches long overall. One end is turned small for 5 inches and the other for 9⅜ inches. On this job five steadyrests are used. The type of shoe used is that known as a solid shoe, and the steadyrests are the Brown & Sharpe combination plain and rigid type.

Steadyrest Work-shoes

The work-shoes used in steadyrests are made from hardened steel, cast iron, bronze, and various kinds of wood. Each material has some particular advantage on certain classes of work, and in the following an endeavor will be made to cover briefly some of the principal uses for the different types of work-shoes. *A* in Fig. 12 shows the simplest type of shoe, where only one is used. As a rule, this shoe is made from wood—generally hard maple or hickory. When the work is comparatively heavy, however, a wooden shoe is not recommended, and as a rule soft metal shoes are used instead. The wooden shoes, of course, have the advantage of being more readily adapted to the work than a metal one, and where only a few pieces are being ground a wooden shoe is recommended.

At *B* in Fig. 12 is shown another application of steadyrest shoes in which two shoes made from hard wood, either maple or hickory, are used. The best form of shoe for cylindrical grinding is that which forms two segments of an arc, and

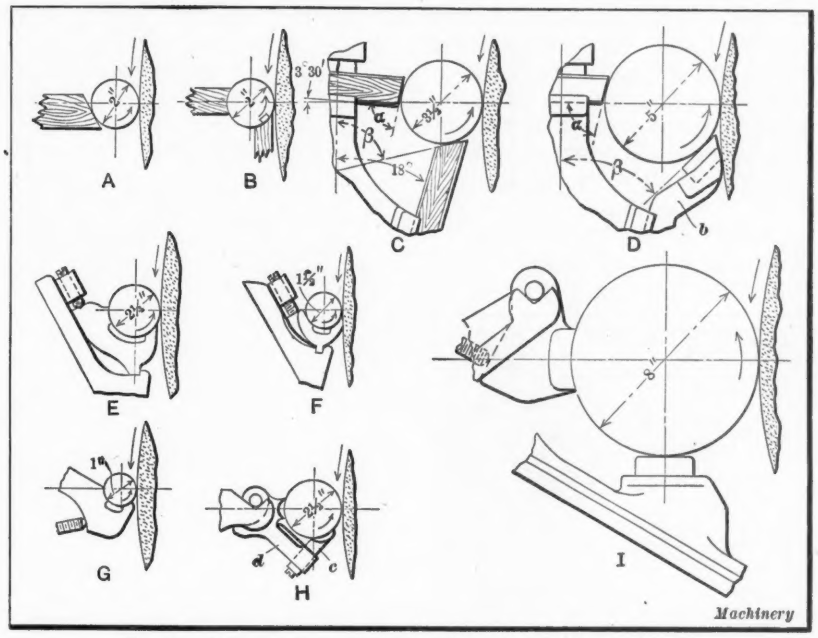


Fig. 12. Different Types of Steadyrests used and their Application

covers about half the circumference of the work being ground. Wood, of course, is the best material for a shoe of this kind; first because of its cheapness and second because of the facility with which it can be adapted to conform to the shape of the work. A shoe of the type shown at *B* in Fig. 12 should have two movements—one horizontal and one vertical. In this illustration a keyway is shown in the work, which brings up a point regarding the amount of bearing surface of the shoe on the work. This should never be less in width, of course, than any slot that is in the work. In applying the shoes to the work, the lower shoe should be placed as near the wheel as possible and the upper one on the center line as shown in the illustration.

Still another application of wooden shoes is shown at *C* in Fig. 12. These shoes are for use in the rigid type of steadyrest and the angle is changed according to the diameter of the work, as given in the following table. Hard maple shoes are used for supporting work from 1 inch up to 4 inches in diameter, but on work larger than this, and up to 8 inches in diameter, as shown at *D*, the lower shoe is usually made of bronze and is held in a special cast-iron holder *b*.

Diameter of Work, Inches	Angle α Degrees	Angle β Deg.	Angle β Min.
1 to 3½	80	77	30
3½ to 4	80	62	30
4 to 5	80	47	00
5 to 6	80	58	00
6 to 8	80	67	30

E in Fig. 12 shows another type of work-holding shoe which is used in the solid type of steadyrest and made from steel hardened and ground to size. This shoe is quickly put in place or removed from the holder and is clamped by a screw. It is recommended for use on duplicate work where a large number of pieces of one diameter are to be ground, and is of particular advantage on hardened work.

A shoe differing but slightly in construction from that shown at *E* is shown at *F*. This type of shoe is used in the production of small-diameter work on large size machines. It is made from a hardened and ground steel, and is applied to the work as shown in the illustration. This type of shoe is also recommended for hardened work and for work that must be turned out in large quantities.

Still another type of shoe is shown at *G* in Fig. 12. This shoe is generally adapted for a spring steadyrest, is made from bronze, and a different size shoe has to be provided for each variation in the diameter of the work. It is particularly adapted for work requiring a fine degree of accuracy and for shafts that are keyseated, and, in fact, for all work under 1 inch in diameter. Its use is strongly recommended where a large amount of work of one diameter is to be ground.

The steadyrest shoes shown at *H* are generally used in a spring type of steadyrest, and are known as the adjustable type. The lower shoe *c* is adjustable along the bar *d* to accommodate various diameters of work. These shoes are made from bronze and are used where only a small number of pieces of one size are being turned out.

On work of large diameter, where the ordinary spring rest is not sufficiently rigid to support it, the application of work-shoes as shown at *I* in Fig. 12 is recommended. In this illustration, it will be noticed that two shoes are used to support the work against the thrust of the wheel. The horizontal shoe can, if necessary, be spring-operated or rigid, whereas the entire weight of the work is supported on an adjustable solid shoe, mounted in a holder and capable of adjustment in an inclined plane. In this way a great part of the weight of the work is taken off the centers of the machine and carried by the lower shoe, the other shoe additionally supporting the work against the thrust of the wheel and eliminating chatter and vibration.

As previously mentioned, the type of work-shoes used de-

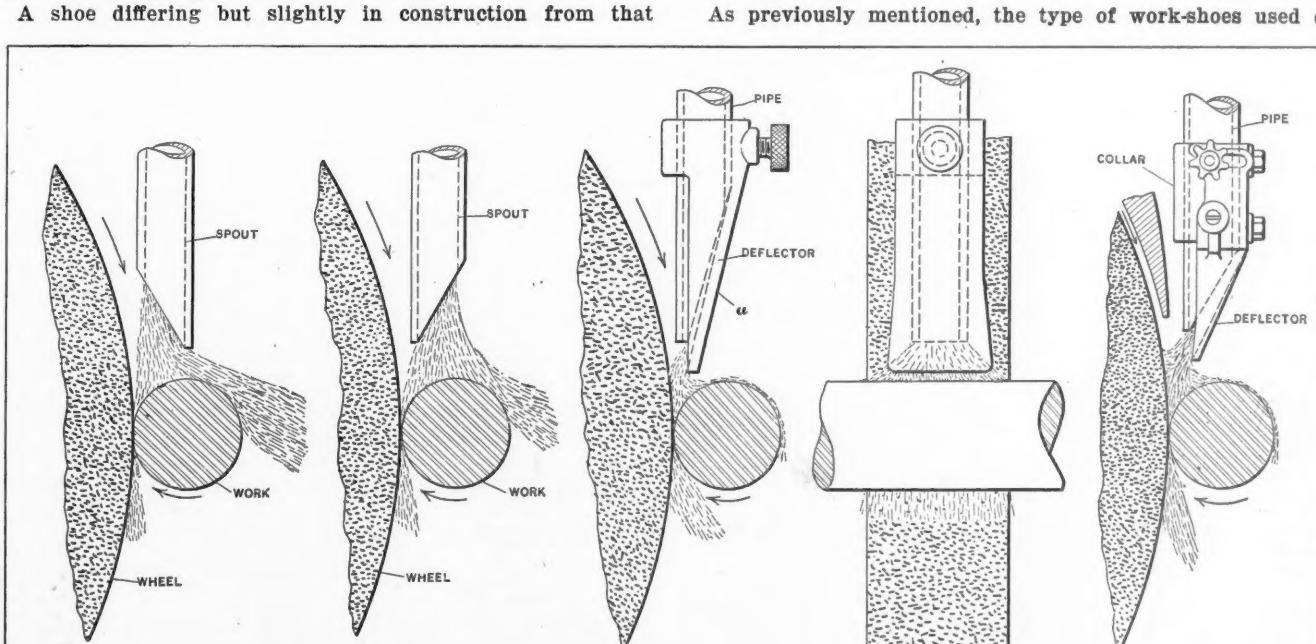


Fig. 13. Application of Water Nozzles to Cylindrical Grinding Machine

pends largely on the requirements of the work, its diameter and the number of pieces turned out. When only a few pieces of work of a certain size are to be turned out, wooden shoes made from either hickory or hard maple are recommended. When a large number of pieces of small diameter are being made, the shoes illustrated at *E*, *F*, and *G* are recommended. Where large-diameter work is to be handled, the shoes illustrated at *D* and *I* are recommended.

Lubricants for Cylindrical Grinding

The problem of finding a suitable lubricant to carry off the heat is probably more important in grinding than in any

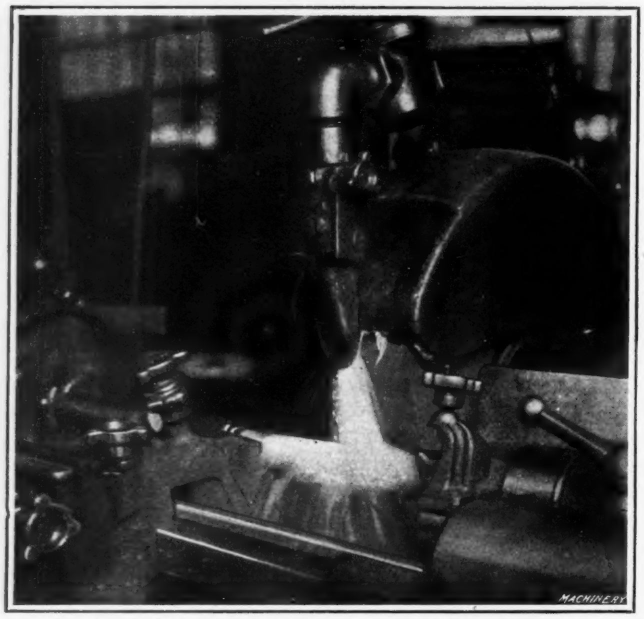


Fig. 14. Satisfactory Application of Water Nozzle shown at E in Fig. 13

other metal cutting operation. The heat generated by the friction of the wheel on the work does not appreciably affect the wheel, but it distorts and injures the work, especially when it is hardened. The most common lubricant for grinding is plain water, but as this causes rusting of the machine parts, it is advisable to mix certain ingredients with the water to overcome the tendency to corrode. In order to prevent rusting, just enough sal-soda should be used in the water to show on the machine and the finished work when dry, and as

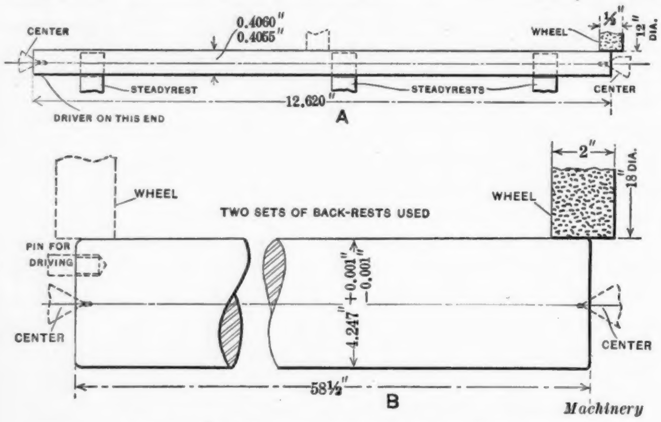


Fig. 15. Examples of Traverse Grinding illustrating Cases where Steadyrests are Necessary

A

Work:—Sewing machine shaft, 0.20 per cent carbon steel, casehardened.

Operation:—Grinding entire length of shaft with a Norton (elastic) alundum wheel, grain 36, grade 5; 12 inches diameter, ½ inch face; speed 1910 R. P. M.—6000 feet surface speed; work speed, roughing, 218 R. P. M.—23 feet surface speed; work speed, finishing, 306 R. P. M.—34 feet surface speed; amount removed from diameter, 0.006 inch.

Remarks:—Traverse method of grinding used at the rate of 30 linear inches per minute; roughing and finishing cuts taken; shaft reversed end for end; completely roughed out before finishing; 0.001 inch left on diameter for finishing; depth of cut, roughing 0.001 inch; 0.0005 inch, finishing; put through in lots of 500; approximate number of traverses, four roughing, four finishing; handled four times; production, 15 per hour, greatly limited on account of slenderness of work and care exercised so as not to remove casehardened surface; for roughing, two spring rests are used, and for finishing, a follow rest is used. (See illustration.) Machine used, No. 11 Brown & Sharpe plain grinding machine.

B

Work:—Over-arm for milling machine, 0.20 per cent carbon machinery steel, not hardened.

Operation:—Rough- and finish-grinding external diameter; roughing with a Carborundum Co.'s aloxite (vitrified) wheel, grain 2411, grade L; 18 inches diameter, 2 inch face; speed, 1273 R. P. M.—6000 feet surface speed; for finishing with a Carborundum Co.'s aloxite (vitrified) wheel, grain 40, grade M; 18 inches diameter, 2 inch face; speed 1167 R. P. M.—5500 feet surface speed; work speed, roughing, 51 R. P. M.—57 feet surface speed; work speed, finishing, 51 R. P. M.—57 feet surface speed, and 70 R. P. M.—79 feet surface speed; amount removed from diameter, 0.020 inch.

Remarks:—Traverse method of grinding used; for roughing, work is traversed past wheel six times at a traverse speed of 66 linear inches per minute, bringing work down to within 0.002 to 0.003 inch of finished diameter; 15 pieces to each truing of wheel; grinding time, 11.76 minutes; for finishing, work is traversed past wheel six times, five traverses at 66 linear inches per minute; last traverse at 25 linear inches per minute, rotated at 70 R. P. M.—79 feet surface speed; four pieces to each truing of wheel; actual grinding time, 12.12 minutes; total grinding time, 23.9 minutes; machine used, Norton plain grinding machine.

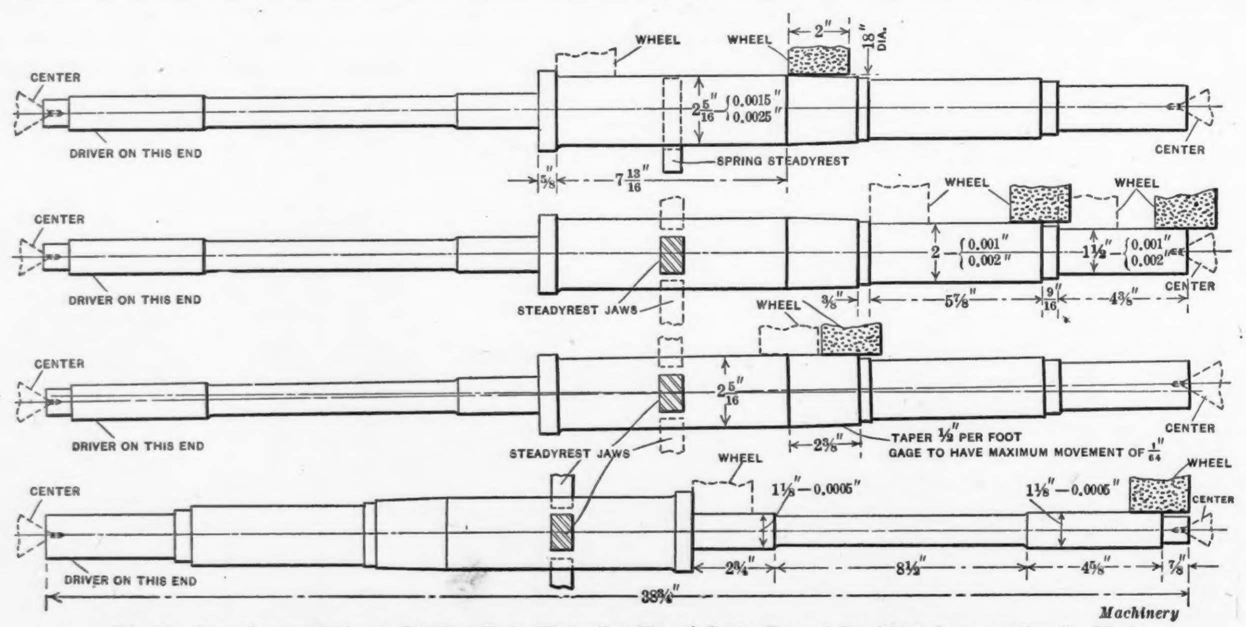


Fig. 16. Example of grinding a Shoulder Shaft illustrating Use of Center Type of Steadyrest for supporting the Work

Work:—Shaft, 0.20 per cent carbon steel, not hardened.

Operation:—Grinding six external diameters with an American (vitrified) corundum wheel, grain 46, grade K; 18 inches diameter, 2 inch face; speed, 1485 R. P. M.—7000 feet surface speed; work speed, roughing, 55 R. P. M.—25 feet average surface speed; finishing 98 R. P. M.—45 feet average surface speed; amount removed from diameter 0.015 to 0.018 inch.

Remarks:—Power traverse is used for grinding all diameters at the rate of 60 linear inches per minute; traverse cut, 0.001 inch deep for roughing, 0.0005 inch for finishing; wheel trued up after grinding each shoulder; work put through in lots of 50 pieces; handled six times before finished; difficult job to grind because of small diameter at one end; for method of supporting, see illustration; last three settings accomplished by using a standard type of center steadyrest; production, 1½ hour per shaft; machine used, No. 12 or 14 Brown & Sharpe plain grinding machine.

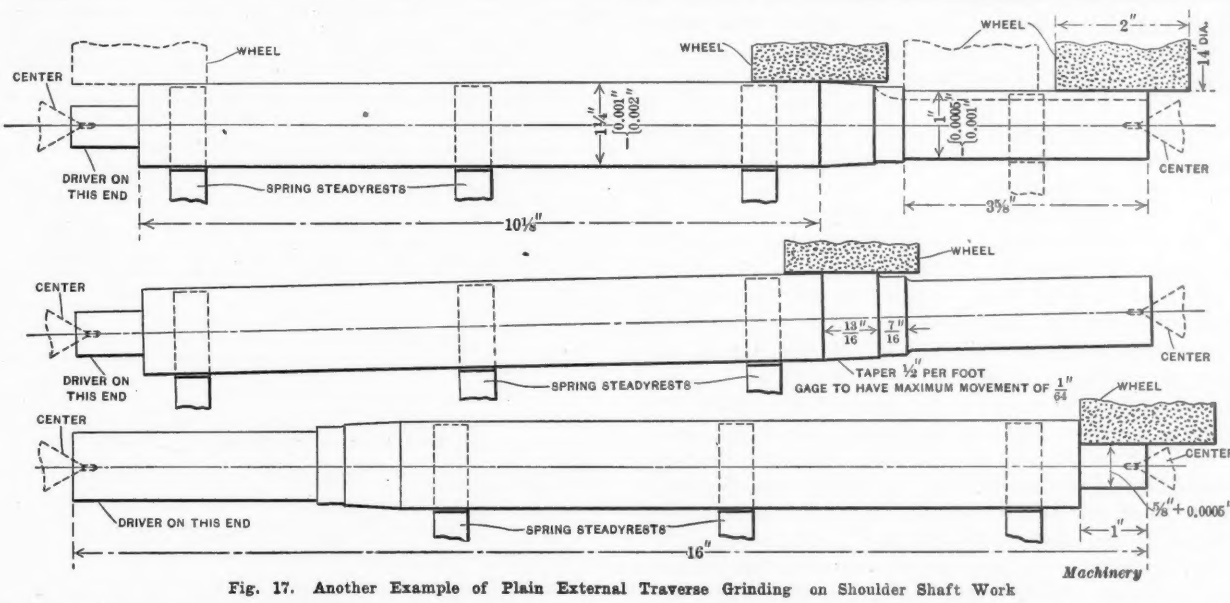


Fig. 17. Another Example of Plain External Traverse Grinding on Shoulder Shaft Work

Work:—Shaft, 0.20 per cent carbon machinery steel, not hardened.

Operation:—Grinding four external diameters with a Carborundum Co.'s (vitrified) aloxite wheel, grain 401, grade M; 14 inches diameter, 2 inch face; speed, 1910 R. P. M.—7000 feet surface speed; work speed, roughing, 172 R. P. M.—50 feet average surface speed; finishing, 258 R. P. M.—65 feet average surface speed; amount removed from diameter, from 0.010 to 0.015 inch.

Remarks:—Traverse method of grinding used at the rate of 120 linear inches per minute; roughing and finishing cuts taken from all diameters ground: 0.001 inch left on all diameters for finishing; depth of cut, roughing, 0.001 inch; 0.0005 inch, finishing; put through in lots of 50 pieces; production, 7 shafts per hour; greatly limited on account of small diameter at one end; taper bearing ground in separate setting (see illustration) and must be concentric with other diameters; four spring type steadyrests for first setting, and three spring type steadyrests for other settings (see illustration); 30 pieces turned out per each truing of wheel; machine used, No. 11 Brown & Sharpe plain grinding machine.

an extra precaution, the machine can be painted with cosmoline, but as a rule this is not necessary.

Grinding on a small variety of work in the tool-room is sometimes done dry, but for manufacturing grinding operations, dry grinding is not recommended as being satisfactory. Work that will grind smooth with water or other cutting lubricants will often develop minute vibrations when grinding dry. There is apparently a rapid fluctuation of temperature which causes the work to recede from and approach toward the wheel very rapidly, thus leaving a mottled or rough surface. In order to obtain smooth and accurate work, the water should run upon the work smoothly and not fluctuate. A fluctuating supply will sometimes cause variation in the cut of the wheel, tending to mar the work, and will, as a rule, show a change of sparks.

As was previously stated, getting rid of the heat is one of the difficult problems encountered in grinding, and in order to reduce the temperature of the work while being ground, as well as to keep the wheel clean, various cutting compounds have been devised. The aim in view, of course, is to get some liquid which will have the maximum cooling effect on the work and at the same time will not rust or gum the machine or mar the surface of the work. "Aquadag" is one of the compounds used with satisfaction for grinding. The

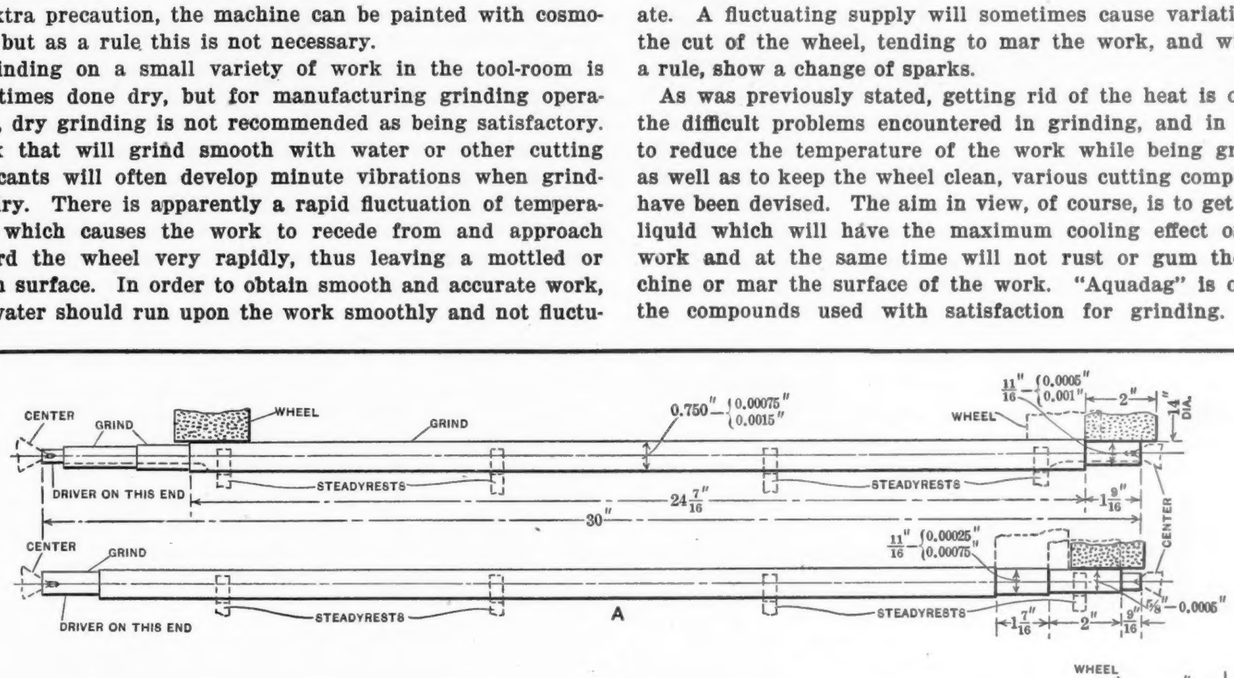


Fig. 18. Two Extreme Examples of Traverse Grinding—One a Long, Slender Shaft and the other a Milling Machine Spindle having Several Shoulders and proportionately Larger in Diameter than in Length. These illustrate Good General Applications of Steadyrests

A

Work:—Shaft, 0.20 per cent carbon machinery steel, not hardened.

Operation:—Grinding four diameters with a Norton (vitrified) alundum wheel, grain 38-36, grade L; 14 inches diameter, 2 inch face; speed 1910 R. P. M.—7000 feet surface speed per minute; work speed for roughing, 194 R. P. M.—35 feet average surface speed; work speed for finishing—300 R. P. M.—55 feet surface speed; amount left on diameters for grinding, 0.010 to 0.015 inch.

Remarks:—Power traverse is used for grinding all diameters at the rate of 96 linear inches per minute; 20 diameters turned out to each truing of wheel; traverse cut, 0.001 inch deep roughing; 0.0005 inch deep finishing; work put through in lots of 50 pieces; four steadyrests of the spring type used; (see illustration for location); production, 3 shafts finished complete per hour; machine used, No. 11 Brown & Sharpe plain grinding machine.

B

Work:—Machine spindle, "Union" drawn steel, casehardened.

Operation:—Grinding seven external diameters with a Norton (vitrified) alundum wheel, grain 38-46, grade K; 14 inches diameter, 1½ inch face; speed, 1776 R. P. M.—6500 feet surface speed; work speed, roughing, 221 R. P. M.—65 feet average surface speed; finishing 289 R. P. M.—85 feet average surface speed; amount removed from all diameters from 0.015 to 0.025 inch.

Remarks:—Power traverse is used for grinding all diameters at the rate of 80 linear inches per minute; 0.003 to 0.004 inch is left for finish-grinding; 50 pieces turned out to each truing of wheel; put through in lots of 50; production, 50 in twenty-four hours; machine used, No. 11 Brown & Sharpe plain grinding machine.

method of using this mixture is to take a No. 10 jar of "Aquadag" and mix it with ten gallons of water; then add ½ pound of borax or sal-soda to prevent the machine rusting. This should be applied to the work in the same manner as water.

The grinding of aluminum has always given more or less trouble because as soon as the work begins to heat the chips cut out by the wheel do not free themselves, but clog the wheel and the wheel glazes rapidly, producing an unsatisfactory surface on the work. Various lubricating compounds have been used for grinding aluminum, but a lubricant composed of equal parts of light spindle oil and kerosene has been found to give satisfactory results. On one particular job of grinding, which was a small spindle made from cast macadamite, practically every cutting lubricant on the market, as well as soap, soda and water, were tried without satisfaction. The operator accidentally dropped some spindle oil on the work while oiling up the machine, and when the work was ground, this part showed a better finish than any other part of the work. A mixture of spindle oil and kerosene was then used, and the results were all that could be desired.

For form grinding, the Ford Motor Co. uses soap, sal-soda, lard oil and water. This is made up in the following order: First, a mixture of soap and lard oil of equal parts is made and boiled. While this is still hot fifteen parts of water are added. The water, previous to being put in the soap and lard oil solution, is prepared with fifteen parts of water to one of sal-soda, and this proportion is varied according to the work upon which the lubricant is to be used. For form grinding vanadium steel drop-forgings, a mixture of fifteen parts of water to one of sal-soda is generally used.

The character and shape of the work has a considerable bearing on the cutting lubricant used. For instance, shoulder shafts which are not provided with recesses at the shoulders require a very thin lubricant. The reason for this is that the heavier lubricants collect in a mass at the shoulders, and thus make it difficult for the operator to see when the wheel reaches the shoulder. For work of this character, a solution of sal-soda and water has been found most satisfactory.

Shape and Action of Water Nozzles for Cylindrical Grinding

The application of water or other cooling mediums to the work when grinding is a matter that does not always receive the attention that it deserves. In rapid production work in which the same care cannot be exercised as in toolroom grinding, it is necessary that every provision be made for eliminating those factors which tend to produce poor work. One of these factors is improper cooling. The first nozzles used in connection with universal grinding machines were small spouts held in a frame into which the water was conveyed by means of a pipe. These spouts discharged a very small stream of water on the work which assisted somewhat in preventing the work from excessive heating. With the wheels used at that time, the amount of water required was not very great, so that very little trouble was experienced in the nozzle arrangement.

Following the use of increased widths of grinding wheels, the problem of keeping the work cool became more and more difficult. The diagram shown in Fig. 13 presents some of the different types of water nozzles used. At *A* in Fig. 13 is shown a plain pipe water nozzle, but the position of this nozzle has been reversed, so that it works unsatisfactorily, and has a tendency to splash the operator. The reason for this is that the capillary attraction between the water and the surface of the pipe causes it to cling to the "long side," and the consequence is that it is attracted toward or thrown away from the wheel instead of onto it. Of course, the air current set up by the revolving wheel has a tendency to draw some of the water in, but as water is heavier than air it penetrates these air currents to a certain extent.

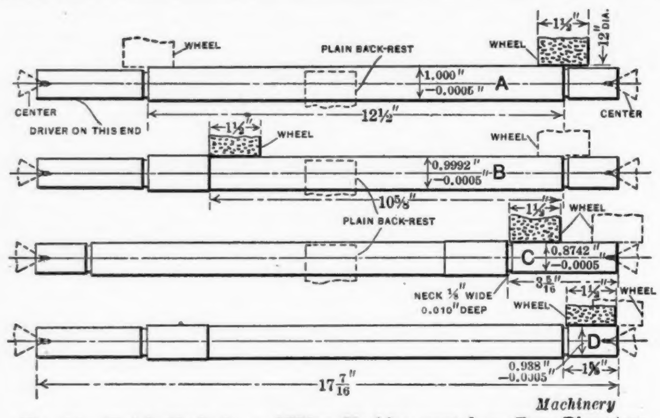


Fig. 20. Clutch Shaft for a Milling Machine ground on Four Diameters in a Total Time of 11.7 Minutes for Each Shaft

Work:—Clutch shaft for milling machine, 0.15 per cent carbon machinery steel, not hardened.

Operation:—Grinding four diameters with a Carborundum Co.'s (vitrified) aloxite wheel, grain 365, grade M; 12 inches diameter, 1½ inch face; speed, 1910 R. P. M.—6000 feet surface speed; work speeds, 170, 190 and 200 R. P. M.—46 feet surface speed; amount removed from diameter, 0.015 inch.

Remarks:—Traverse method of grinding used; on diameter (A) work is fed past wheel twice and wheel fed in to depth, then two traverses made with wheel "fixed"; table traversed at rate of 18 linear inches per minute; 15 pieces to each truing of wheel; grinding time, 5.9 minutes; on diameter (B) wheel is fed in to depth and work traversed twice past wheel at a table traverse of 18 linear inches per minute; 25 pieces to each truing of wheel; grinding time, 2.3 minutes; on diameter (C) wheel is fed in to depth on work and work traversed past it four times by hand, the first traverse at 10 linear inches per minute, and last three traverses at 20 linear inches per minute; 20 pieces to each truing of wheel; grinding time, 2.02 minutes; on diameter (D) wheel is fed in to depth on work and work traversed four times past it by hand, the first traverse at 10 linear inches per minute, the last three traverses at 20 linear inches per minute; 30 pieces to each truing of wheel; grinding time, 1.49 minute; total grinding time for each shaft, 11.7 minutes; machine used, Norton plain grinding machine.

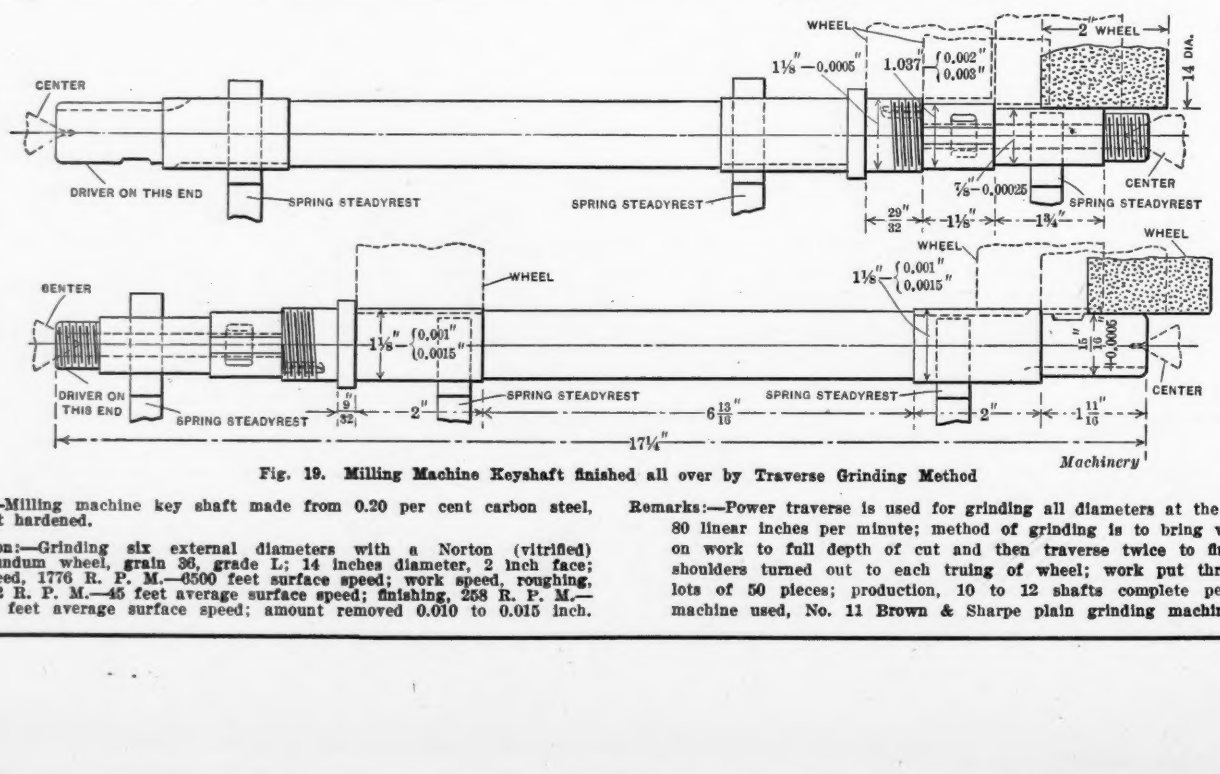


Fig. 19. Milling Machine Keyshaft finished all over by Traverse Grinding Method

Work:—Milling machine key shaft made from 0.20 per cent carbon steel, not hardened.

Operation:—Grinding six external diameters with a Norton (vitrified) alundum wheel, grain 36, grade L; 14 inches diameter, 2 inch face; speed, 1776 R. P. M.—6500 feet surface speed; work speed, roughing, 172 R. P. M.—45 feet average surface speed; finishing, 258 R. P. M.—67 feet average surface speed; amount removed 0.010 to 0.015 inch.

Remarks:—Power traverse is used for grinding all diameters at the rate of 80 linear inches per minute; method of grinding is to bring wheel in on work to full depth of cut and then traverse twice to finish; 50 shoulders turned out to each truing of wheel; work put through in lots of 50 pieces; production, 10 to 12 shafts complete per hour; machine used, No. 11 Brown & Sharpe plain grinding machine.

The proper way of placing a nozzle of the type shown at *A* is shown at *B*. In this case it will be noticed that the angular face is not presented to the wheel but away from it. Here capillary attraction tends to direct the water in the way it should go. It will be noticed, however, that considerable splashing of the water is still present. One means of overcoming this is to use a deflector *a*, as shown at *C*, which can be adjusted so as to control the flow of the water. This prevents the water from splashing over the operator and directs it to the cutting point of the wheel on the work, where it is most needed. The lower end of the water nozzle spout and the deflector should be so shaped that the water is directed to cover the full face of the grinding wheel used. If one or both edges of the wheel are allowed to cut dry, the surface finish may be marred by feed lines, so that to secure good work it is necessary to cover the entire cutting surface of the wheel with the cooling lubricant.

The diagram at *E* shows another type of adjustable water nozzle, in which case the deflector can not only be moved up and down by adjusting it along the pipe, but it is also capable of an in-and-out movement that enables the operator to direct the stream of cooling lubricant where it is most needed. This nozzle is also so constructed and adjusted that the stream of water or cutting lubricant is directed to cover the full face of the grinding wheel.

Fig. 14 shows a satisfactory application of a water nozzle, but in this case the deflector has been set out from the wheel too far so that the water is sprayed considerably over the

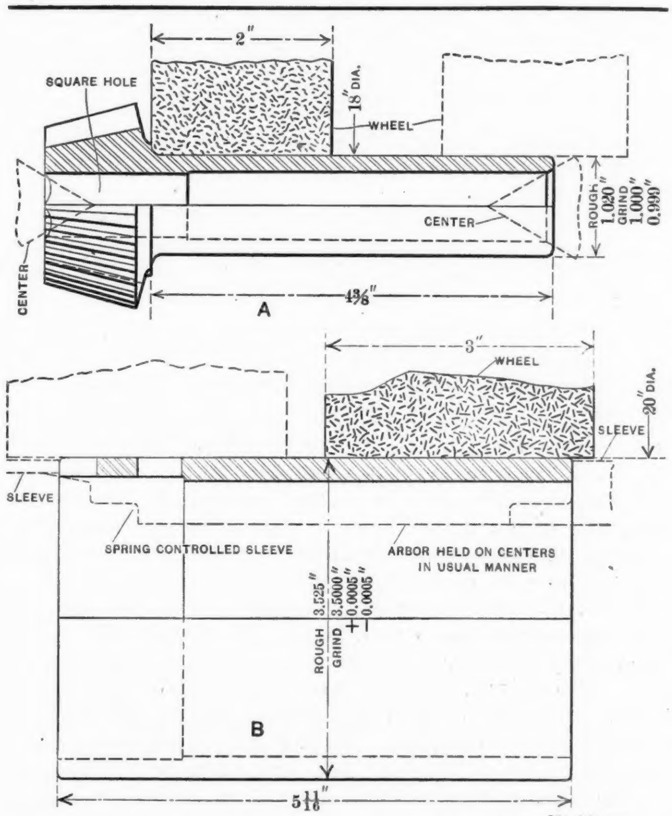


Fig. 21. Examples of Traverse and "Step-in" Methods of Grinding

A

Work:—Bevel main drive pinion, chrome-vanadium steel, oil-hardened.

Operation:—Grinding external diameter with a Norton (vitrified) alundum wheel, grain 24, grade M: 18 inches in diameter, 2 inch face; speed, 1100 R. P. M.—5200 feet surface speed; work speed, 80 R. P. M.—21 feet surface speed; amount removed from diameter, 0.020 inch.

Remarks:—"Step-in" method of grinding in conjunction with traverse for finishing is used; production, 25 to 30 pieces per hour; machine used, 10 by 36 inch Norton plain grinding machine.

B

Work:—Main drive gear bearing sleeve, 0.15 carbon open-hearth Shelby seamless steel tubing, carbonized 0.030 inch deep and oil-hardened. Must strike 70 on the scleroscope.

Operation:—Grinding external diameter with a Norton (vitrified) alundum wheel, grain 24, grade M; 20 inches diameter, 3 inch face; speed, 1065 R. P. M.—5576 feet surface speed; work speed, 82 R. P. M.—74 feet surface speed; amount removed from diameter, 0.025 inch.

Remarks:—Power traverse is used and eight traverses at the rate of 56 linear inches per minute are required; wheel is fed in to a depth of approximately 0.003 inch per traverse for roughing out; production, 125 pieces in nine hours; machine used, 10 by 36 inch Norton plain grinding machine.

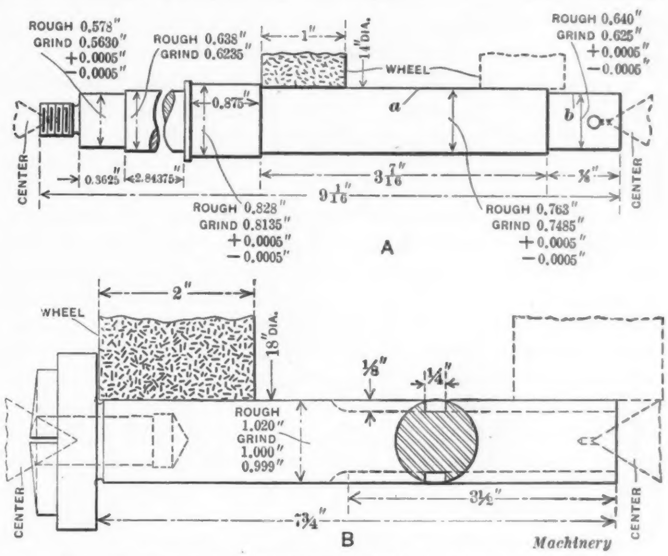


Fig. 22. Examples illustrating "Step-in" Method of grinding Cylindrical Work

A

Work:—Magneto and pump drive shaft, 0.50 per cent open-hearth steel, not hardened.

Operation:—Grinding external diameters with a Norton (vitrified) alundum wheel, grain 60, grade N; 14 inches diameter, 1 inch face; speed, 2000 R. P. M.—7320 feet surface speed; work speed, 400 R. P. M.—72 feet average surface speed; amount removed from diameter, 0.015 inch.

Remarks:—"Step-in" method of grinding in conjunction with traverse is used; two minutes to grind bearing (a); production, 240 for the large diameter (a), and 300 for the small diameter (b) in nine hours; machine used, Morse Twist Drill Co. plain grinding machine.

B

Work:—Transmission main drive pinion, chrome-vanadium steel, oil-hardened.

Operation:—Grinding external diameter with a Norton (vitrified) alundum wheel, grain 24, grade M; 18 inches diameter, 2 inch face; speed, 1100 R. P. M.—5200 feet surface speed; work speed, 80 R. P. M.—21 feet surface speed; amount removed from diameter, 0.020 inch.

Remarks:—"Step-in" method of grinding in conjunction with traverse is used; four cuts to finish work; remove 0.001 to 0.002 inch by traverse; three minutes each; machine used, 10 by 36 inch Norton plain grinding machine.

front of the work. By just pushing in this deflector a slight amount, the water can be directed more against the wheel, and will do more effective cooling.

Conditions Governing Amount of Cooling Lubricant to Use

There are several conditions governing the amount of water or other cooling lubricant to use for cylindrical grinding. They are:

1. The larger the work, the greater is the wheel surface in contact and the necessity for a greater supply of cutting lubricant.
2. An increased width of wheel face increases the amount of surface contact, and necessitates a greater amount of lubricant.
3. An increase of work speed necessitates an increase in the amount of cooling lubricant.
4. Some materials require more cooling lubricant than others because of their nature. For instance, hardened steel requires more cooling lubricant than soft steel if satisfactory wheels are used in both cases.

In all cases, the water supply should be sufficient to keep the work as cool as possible, and at the same time cover the entire face of the grinding wheel. Usually the pump supplied with the grinding machine is capable of being speeded up so that the amount of water supplied to the machine can be varied independently of the position of the valve opening in the supply pipe.

The pumps supplied with the plain type of grinding machine are generally of the fan type and vary in capacity from 5 to 100 quarts per minute. This type of pump is rotated at from 500 to 1200 revolutions per minute. The amount of cooling lubricant generally required for plain cylindrical grinding operations varies from 1 to 30 gallons per minute. For a wheel having, say, a 2-inch face, and grinding by the traverse method, the amount of cooling lubricant supplied would be in the neighborhood of 3 to 5 gallons per minute. Of course the amount of lubricant required is dependent entirely upon the width of wheel used, speed of work and nature of material, and as the capacity of the pump can be increased, it is

a comparatively easy matter to secure the desired amount of cooling lubricant.

Examples of Plain Cylindrical Grinding

An endeavor has been made in the preceding to take up the various factors connected with the successful accomplishment of grinding operations, touching on some of the most important features. Grinding, however, is such a broad subject and the methods of accomplishing various results differ so widely that a description of any one phase must necessarily be incomplete. While it must be admitted that there are certain underlying factors that remain practically unchanged, it is nevertheless a fact that what would be considered good practice in one shop is not so considered in another; hence, the difference of opinion and methods of procedure. In order to cover every phase of the grinding subject as thoroughly as possible, it has been thought advisable, after considerable study and investigation, to show concrete examples of various classes of work, and from these draw conclusions that should be of value to grinding machine operators in general.

One of the first methods used in producing cylindrical work by grinding was by traversing a narrow face wheel past the work or the work past the wheel, depending on the type of machines used. While great advances have been made in cylindrical grinding, a large amount of work is still produced by the traverse method, but instead of using narrow face wheels much wider wheels and heavier machines are now used for this purpose.

Grinding Long, Slender Shafts

Long, slender shafts have always presented considerable difficulty in grinding. First, because of the liability of the work to spring and vibrate, and second, because of the difficulties met in securing accurate work. The sewing machine shaft shown at *A* in Fig. 15 is a good illustration of this point. This shaft is made from 0.20 per cent carbon steel, casehardened, and it must be ground for its entire length to a limit of 0.0005 inch on the diameter. The liability to

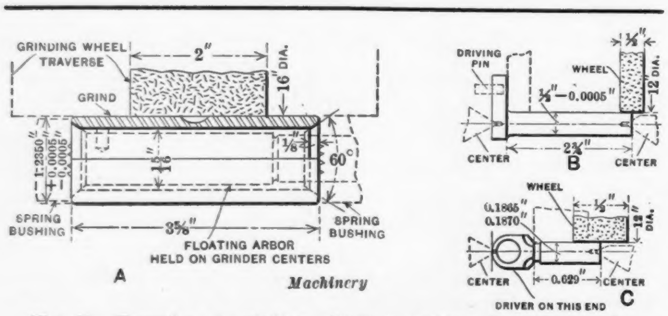


Fig. 23. Examples of grinding "Shelby" Tubing, Cast Macadamite, and a Sewing Machine Plunger—All Accurate Work—bringing up Different Points in Cylindrical Grinding

A

Work:—Piston pin made from Shelby steel tubing containing 0.15 to 0.25 per cent carbon, carbonized 0.030 inch deep and hardened in oil.

Operation:—Grinding external diameter with a Norton (vitrified) alundum wheel, grain 46, grade K; 16 inches diameter, 2 inch face; speed 1600 R. P. M.—6700 feet surface speed; work speed, 176 R. P. M.—56 feet surface speed; amount removed from diameter, 0.015 inch.

Remarks:—Wheel is fed in almost to depth, then traversed once across by hand; then power feed is thrown in and four traverses made at a traverse speed of 40 inches per minute; work held on a special arbor, two provided; production, 240 in nine hours; machine used, 10 by 36 inch Norton plain grinding machine.

B

Work:—Crank lever made from cast macadamite.

Operation:—Grinding stem with a Norton (elastic) alundum wheel, grain 120, grade 2½; 12 inches diameter, ½ inch face; speed, 2070 R. P. M.—6500 feet surface speed; work speed, 459 R. P. M.—60 feet surface speed; amount removed from diameter, 0.010 inch.

Remarks:—Traverse method of grinding used at the rate of 60 inches per minute; 0.0005 inch depth of cut per traverse of wheel; 120 pieces turned out to each truing of wheel; kerosene and spindle oil mixed half and half used as a cooling lubricant; production, 60 per hour; machine used, No. 11 Brown & Sharpe universal grinding machine.

C

Work:—Sewing machine plunger, 0.20 per cent carbon steel, casehardened.

Operation:—Grinding external diameter of stem with a Norton (elastic) alundum wheel, grain 36, grade 5; 12 inches diameter, ½ inch face; speed, 1910 R. P. M.—6000 feet surface speed; work speed, roughing, 510 R. P. M.—25 feet surface speed; finishing, 714 R. P. M.—35 feet surface speed; amount removed from diameter, 0.006 inch.

Remarks:—Traverse method of grinding used; table traversed by hand; approximate number of traverses, 4; put through in lots of 5000; production, 145 per hour; machine used, No. 11 Brown & Sharpe plain grinding machine.

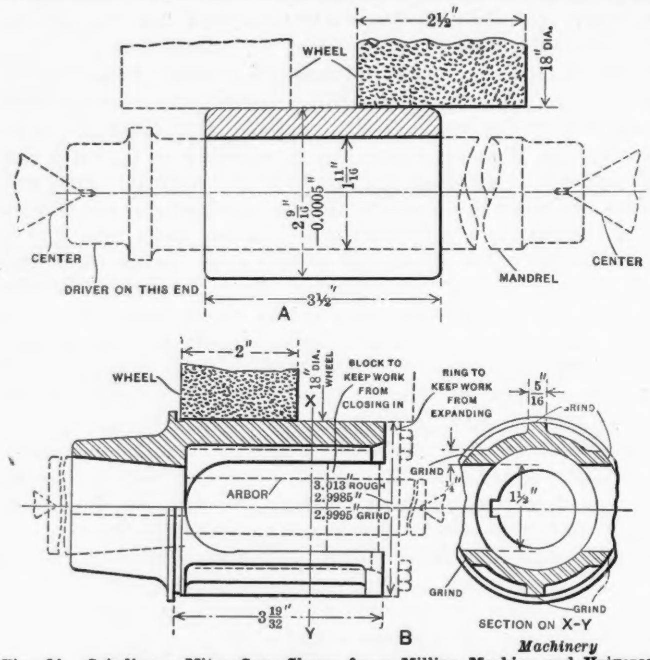


Fig. 24. Grinding a Miter Gear Sleeve for a Milling Machine and Universal Drive Shaft Yoke for an Automobile. The Latter Example illustrates a Difficult Holding Proposition

A

Work:—Miter gear sleeve for milling machine, made from cast iron.

Operation:—Grinding external diameter with a Carborundum Co.'s (vitrified) carborundum wheel, grain 40, grade P; 18 inches in diameter, 2½ inch face; speed, 1273 R. P. M.—6000 feet surface speed; work speed, 80 R. P. M.—55 feet surface speed; amount removed from diameter, 0.015 inch.

Remarks:—"Fixed-wheel" method of grinding used; wheel fed in to depth and work traversed past wheel four times; first by hand at the rate of 15 linear inches per minute and last three times by power at 25 linear inches per minute; 30 pieces turned out per each truing of wheel; production, 30 per hour; machine used, Brown & Sharpe plain grinding machine.

B

Work:—Universal drive shaft yoke, 0.20 per cent carbon, open-hearth steel carbonized and hardened.

Operation:—Grinding external diameter with a Norton (vitrified) alundum wheel, grain 24, grade M, 18 inches in diameter, 2 inch face; speed, 1200 R. P. M.—5600 feet surface speed; work speed, 80 R. P. M.—63 feet surface speed; amount removed from diameter, 0.020 to 0.025 inch.

Remarks:—"Step-in" method of grinding used, in combination with one traversing cut; production, 20 per hour; machine used, Cincinnati plain grinding machine.

chatter and vibrate is largely overcome by the use of steadyrests, three of which are used for the roughing-out operation, at which time the shaft is reduced to within 0.001 inch of the final diameter. For the finish-grinding operation, the follow type of steadyrest shown in Fig. 10 is used. This rest remains stationary directly in front of the grinding wheel, and provides the necessary support.

Another shaft of a somewhat similar nature, but which is not hardened, is shown at *A* in Fig. 18. In this case, it will be noticed that four steadyrests are used for supporting the work. The shaft is provided with three shoulders, necessitating changing the location of one steadyrest for grinding the work at the second setting. As this shaft is not as slender as the one shown at *A* in Fig. 15, a larger amount is left on the diameter for finish-grinding, varying from 0.003 to 0.004 inch. Another reason why a greater amount is left in this case for finishing is because of the shoulders on the work which must be ground absolutely concentric with each other. Greater stiffness also allows the use of a wider face wheel and permits heavier cuts with a coarser traverse feed to be taken, which it will be noticed is almost three times as great as the traverse feed used for grinding the shaft shown at *A* in Fig. 15.

Grinding an Over-arm for a Milling Machine

The over-arm for a milling machine, shown at *B* in Fig. 15, is a somewhat easier proposition than the slender shaft just described. This is made from 0.20 per cent carbon machinery steel, not hardened, and is rough- and finish-ground in two operations. The work is of such large diameter that a hole can be drilled in the end to carry a driving pin, so that it is not necessary to reverse the work end for end on the centers to complete it. For the grinding of this over-arm, a coarse-

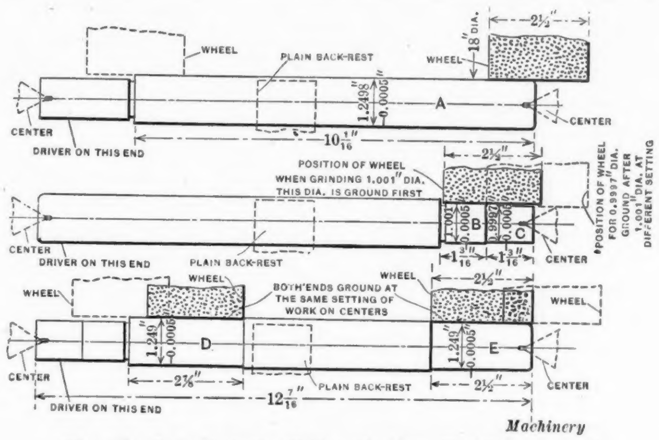


Fig. 25. Fork Shaft for Milling Machine, illustrating a Good Example of the "Fixed-wheel" Method of Grinding

Work:—Fork shaft for milling machine, 0.20 per cent carbon machinery steel, not hardened.

Operation:—Grinding five diameters with a Carborundum Co.'s (vitrified) aloxite wheel, grain 365, grade M, 18 inches diameter, 2½ inch face; speed, 1273 R. P. M.—6000 feet surface speed; work speeds, 140 and 180 R. P. M.—46 and 47 feet surface speed; amount removed from diameter, 0.015 inch.

Remarks:—"Fixed wheel" method of grinding used; for diameter (A) wheel is fed straight in to depth on work, which is traversed once past wheel by hand at 10 linear inches per minute, then power feed is thrown in and three traverses at 20 linear inches per minute are made; 7 pieces to each truing of wheel; grinding time, 4 minutes per piece; on diameter (B) wheel is fed in to depth, and work traversed four times by hand at 20 linear inches per minute; 20 pieces to each truing of wheel; grinding time, 1½ minute; on diameter (C) wheel is fed in to depth, and work traversed twice by hand at 20 linear inches per minute; 30 pieces to each truing of wheel; grinding time, 1.3 minute per piece; on diameters (D) and (E) wheel is fed in to depth, and work traversed twice by hand for each diameter at 20 linear inches per minute; 10 pieces to each truing of wheel; grinding time, 4.4 minutes for both diameters; total time to complete shaft, 9.9 minutes; machine used, Norton plain grinding machine.

grain comparatively hard bond wheel is used for both rough- and finish-grinding, so that in order to get the required finish on the work it is necessary to rotate the work faster for the finishing cut than for the roughing cut, and at the same time reduce the traverse speed of the work past the wheel. By referring to Fig. 15 it will be noticed that for roughing, a surface speed of 57 feet is used, whereas for finishing, two speeds of 57 and 79 surface feet, respectively, are employed. The last traverse is at a work speed of 79 surface feet. The traverse speeds are 66 linear inches per minute for roughing, five traverses at the same speed for finishing, and the last traverse at a speed of 25 linear inches per minute.

Grinding Shoulder Shafts

The shaft shown in Fig. 16, which is made from 0.20 per cent carbon steel, not hardened, has to be ground on six external diameters, one of which is tapered. These operations were performed with a comparatively fine grain, soft bond wheel, running at a peripheral speed of 7000 surface feet. In this case, a work speed of, on an average, 25 surface feet was used for roughing at a traverse speed of 60 linear inches per minute. While finishing, the traverse work speed past the wheel remains the same, but in order to get the desired finish on the work the work speed was increased on an average to 45 surface feet. In this case there are two alternatives for roughing. A sufficiently high work speed could have been used with a greater rate of traverse and the speed of the work and traverse feed could have been reduced for finishing. This illustrates how it is possible to produce the same piece of work by changing the work speed and power traverse and obtain practically the same results. It will also be noticed, upon referring to this illustration, that the method of grinding the various shoulders on this shaft is somewhat out of the ordinary. For the first operation, which is the grinding of the center shoulder, a single spring steadyrest is used. Then for the remaining shoulders, because of the slenderness of the work, the center shoulder is used as a point upon which the work is supported by means of a center type of steadyrest. This left about 19 inches of work unsupported and necessitated taking fine cuts; but owing to the fact that all shoulders were required to be concentric with the center one, this method of supporting was adopted.

A similar example is shown in Fig. 17, where practically all the conditions are reversed. This is due largely to a change in the grinding wheel used. In this case it will be noticed that an average work speed of 50 surface feet is used for roughing and 65 surface feet for finishing. The traverse speed is also increased over that used for the job shown in Fig. 16. In fact, it is doubled. One of the reasons for this is that the shaft is larger in diameter in proportion to its length, and can be much more rigidly supported by steadyrests, four of which are used for grinding the first two diameters and three for the last two settings. The production on this shaft, however, is limited to a certain extent by the small diameter on one end.

An interesting example of plain cylindrical grinding is the milling machine spindle shown at *B* in Fig. 18. This is made from "Union" drawn steel, and presents a difficult grinding proposition, because of the multiplicity of shoulders and the accuracy to which these must be finished. For this particular job, a No. 38 alundum, grain 46, grade K grinding wheel is used. This is a medium soft wheel of fine grain, necessitating a comparatively high work speed to get satisfactory results, which in this case is, on an average, 65 surface feet for roughing and 85 surface feet for finishing. The reason for increasing the work speed for finishing is that the traverse feed remains the same for both operations, or at the rate of 80 linear inches per minute. This brings up a point in regard to the selection of grinding wheels. If this part had been soft instead of casehardened when ground, it could have been satisfactorily ground with a slower work speed; the alternative, therefore, would be to use a slower work speed with a softer bond, coarser grain wheel.

Another example of shoulder shaft grinding is shown in Fig. 19, where the part being ground is a milling machine keyshaft made from 0.20 per cent carbon steel, not hardened. Six diameters on this shaft must be ground to limits varying from 0.0015 to 0.0005 inch. The wheel used is a comparatively fine grain alundum wheel, with a medium soft bond. The work speed is 45 feet average surface speed for roughing, and 67 feet average surface speed for finishing, with a power traverse of 80 linear inches per minute. The method of grinding is to bring the wheel in on the work to the full depth of cut and then traverse twice to finish. The first cut takes about from 0.012 to 0.014 inch from the diameter, and the last one removes from 0.001 to 0.002 inch to finish. In this

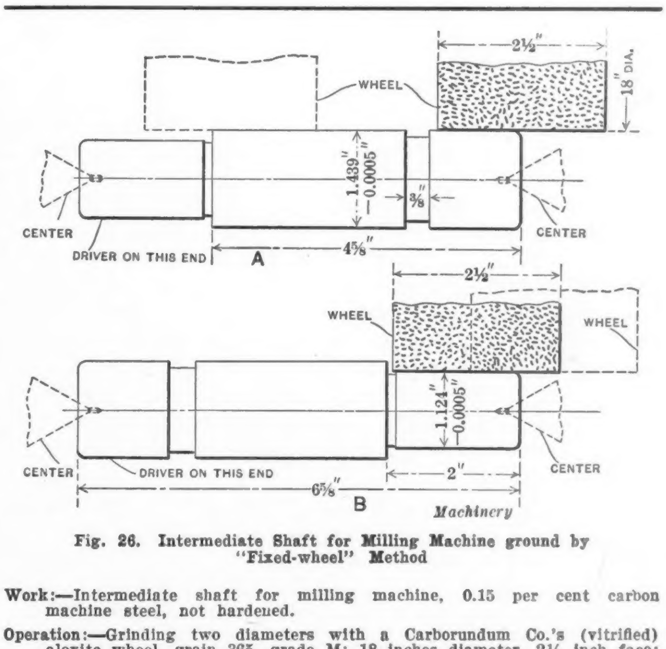


Fig. 26. Intermediate Shaft for Milling Machine ground by "Fixed-wheel" Method

Work:—Intermediate shaft for milling machine, 0.15 per cent carbon machine steel, not hardened.

Operation:—Grinding two diameters with a Carborundum Co.'s (vitrified) aloxite wheel, grain 365, grade M; 18 inches diameter, 2½ inch face; speed, 1273 R. P. M.—6000 feet surface speed; work speed, 128 R. P. M.—38 and 49 feet surface speed; amount removed from diameter, 0.015 inch.

Remarks:—"Fixed wheel" method of grinding used. On diameter (A) wheel is fed straight in to depth, and work traversed past it four times; the first time, by hand at 10 linear inches per minute and last three times by power at 22 linear inches per minute; 13 pieces to each truing of wheel; grinding time, 2.6 minutes; on diameter (B) wheel is fed straight in to depth and then work traversed past it four times at the rate of 20 linear inches per minute, by hand; 20 pieces to each truing of wheel; production, 15 shafts complete per hour; machine used, Norton plain grinding machine.

case it will be noticed also, owing to the disposition of the shoulders, that the position of the steadyrests must be changed for the two settings.

Another interesting method of shoulder shaft grinding is presented in Fig. 20, which shows a clutch shaft for a milling machine. This is made from machinery steel, not hardened. The work speeds for all the various diameters remain practically the same, about 46 feet surface speed, but the rate of traverse for grinding the various diameters is changed. For those shoulders which are comparatively long, a slow traverse speed is used, varying from 10 to 18 linear inches per minute. For the short shoulders, however, the traverse is increased to 20 linear inches per minute. This is due largely to the greater amount of wheel surface in contact with the work.

Grinding a Thin Wall Sleeve

The main drive gear bearing sleeve shown at *B* in Fig. 21 presents a difficult grinding proposition because of the thin walls of the sleeve and the liability to distort it while clamping to grind its external diameter. In order to obviate springing the work, it is held by the ends only, and floats on a special spring arbor. The external diameter is ground first, and then the bushing is located in a close-fitting sleeve chuck and the internal diameter ground. In this way, both internal and external diameters can be ground concentric with each other, and the walls will be of equal thickness all the way around. For grinding this piece, a comparatively high work speed is used, but the power traverse feed is reduced below what would be necessary if a slower work speed were adopted.

Examples of Work Produced by "Step-in" Method of Grinding

As has been previously explained, a large number of concerns are not equipped with grinding machines capable of carrying wide face wheels and have endeavored to increase production by a method which is known as "step-in" grinding. This consists in "stepping" or "butting" the wheel in at intervals along the work to within about 0.001 to 0.002 inch of the final diameter and then making several rapid traverses to finish. A good example of this class of work is shown at *A* in Fig. 21, which is a drive pinion made from a chrome-vanadium steel drop-forging, oil-hardened. A medium grade wheel with a coarse grain is used for this work and it will also be noticed that a comparatively low work speed is used—21 feet surface speed.

Another example of step-in grinding is shown at *A* in Fig. 22. This is a magneto and pump drive shaft made from high-carbon steel, not hardened. The work was done on a comparatively light machine, and in order to increase production the "step-in" method was adopted. It will be noticed in this case that a fine grain, medium bond wheel is used, and consequently a comparatively high wheel speed is necessary—in the neighborhood of 7320 feet. In order to get satisfactory results, it was necessary to increase the work speed to about 72 feet average surface speed. If a heavier machine were used for grinding this part, the wheel speed and work speeds both could have been reduced considerably, and just as good if not better results obtained.

B in Fig. 22 presents another example of "step-in" grinding in conjunction with table traverse. This operation is done on a heavier machine and consequently a medium bond coarse grain wheel is used. A slow wheel speed is also used, together with a slow work speed. This example is in direct contrast to the one shown at *A* in the same illustration, and represents the two methods that can be adopted to accomplish practically the same results on different types of machines with different wheels, wheel and work speeds.

Another interesting sleeve grinding job is shown at *A* in Fig. 23. This is a piston pin, made from "Shelby" steel tubing which is carbonized and hardened in oil. The method of supporting this piece while grinding is similar to that used for supporting the bushing shown at *B* in Fig. 21. A finer grain, softer bond wheel, however, is used, with a higher wheel speed and lower work speed. The method of grinding differs somewhat from that used on the piece shown in Fig. 21; this accounts for the change in the wheel and work speeds. In this case the wheel is fed in almost to depth and then traversed once across by hand, taking a heavy cut, then returned by power, after which four traverses are made at a speed of 40 linear inches per minute.

The sewing machine plunger shown at *C* in Fig. 23 is another interesting example of grinding. This is made from 0.20 per cent carbon steel, casehardened, and the shoulder must be ground to limits of 0.0005 inch on the diameter. Owing to the slenderness of the work and the care which must be exercised in not going below the casehardened surface, this particular piece represents a difficult grinding proposition. The grinding wheel which gave the best results was an alundum, elastic, grain 36, grade 5, rotated at 6000 surface feet, while the work speed was changed for roughing and finishing—25 feet for roughing and 35 surface feet for finishing. This method of handling the work proved satisfactory, as a production of 145 pieces per hour indicates.

Grinding Cast Macadamite

A piece of work which gave considerable trouble before it was ground successfully is the crank lever shown at *B* in

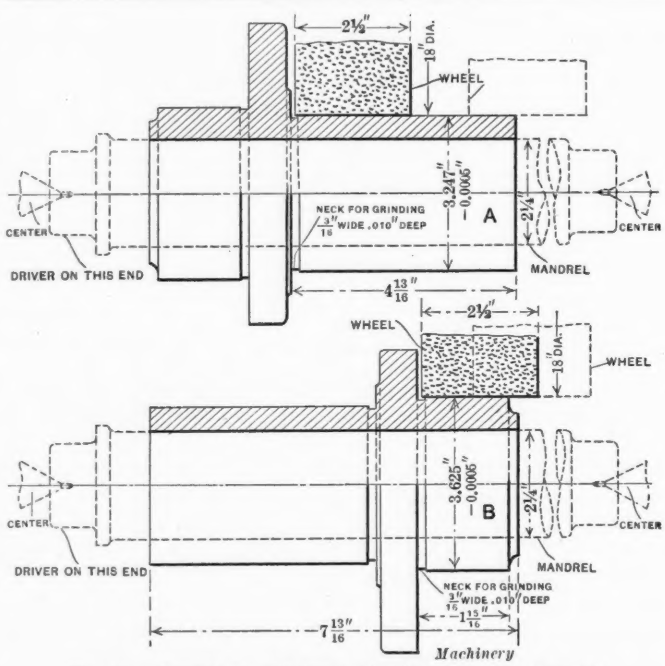


Fig. 27. Example of grinding a Cast-iron Gear Box Bracket by "Fixed-wheel" Method

Work:—Gear box bracket made from iron casting.

Operation:—Grinding two external diameters with a Carborundum Co.'s (vitrified) carborundum wheel; grain 40, grade P; 18 inches diameter, 2½ inch face; speed, 1273 R. P. M.—6000 feet surface speed; work speed, 60 R. P. M.—52 and 57 feet surface speed; amount removed from diameter, 0.017 inch.

Remarks:—"Fixed wheel" method of grinding used; wheel is fed in to depth at shoulder and traversed past work four times, the first traverse at 15 linear inches per minute, the next three traverses at 30 linear inches per minute; on diameter (A) 30 pieces are turned out per each truing of wheel; actual grinding time 4.97 minutes; on diameter (B) 10 pieces to each truing of the wheel, actual grinding time, 4.13 minutes; total grinding time, 9.10 minutes; machine used, Landis plain grinding machine.

Fig. 23, made from cast macadamite. This metal is similar to aluminum, except that it is a little softer. Practically every grade and grain of wheel was tried for this work without success, as well as various lubricating compounds. It was found that the work heated so much, due to the friction of the wheel in contact with it, that it was impossible to get a smooth surface. The problem was finally solved by using a mixture of kerosene and spindle oil mixed in equal proportions as a cooling lubricant. After this lubricant was tried, the wheels were again changed, using softer and harder bond as well as finer and coarser grain, but practically no change was noted on the work, showing that the lubricant solved the problem. It might also be mentioned that this cooling lubricant was also used with success while grinding cast aluminum.

Grinding Universal Drive Shaft Yoke

The universal drive shaft yoke shown at *B* in Fig. 24 was an extremely difficult proposition to handle. This piece is made from 0.20 per cent carbon, open-hearth steel, carbonized and hardened and is completely open on the front end where

the grinding is done. This not only made it difficult to hold the piece rigidly to prevent vibration, but also owing to the openings on each side, the work has a tendency to act as a chisel on the face of the wheel, tearing the abrasive grains from the bond. This problem was solved by holding the work on the tapered end of the arbor, placing a block in the open end to prevent it from collapsing, and then clamping a brace across the front end. A wheel speed of 5600 feet surface speed was used and a work speed of 63 feet surface speed. The method of grinding was to step the wheel in twice along the work almost to the final diameter, and then traverse the work once across and back. By holding the work in this manner, satisfactory results were obtained and a production of twenty per hour secured.

Grinding Shoulder Shafts by the "Fixed-wheel" Method

The fork shaft for a milling machine shown in Fig. 25 was ground by what is known as the "fixed-wheel" method. In this case the wheel was fed straight in on the work to a stop, and then traversed once past the wheel by hand feed and three times by power feed. Fig. 26 shows another piece

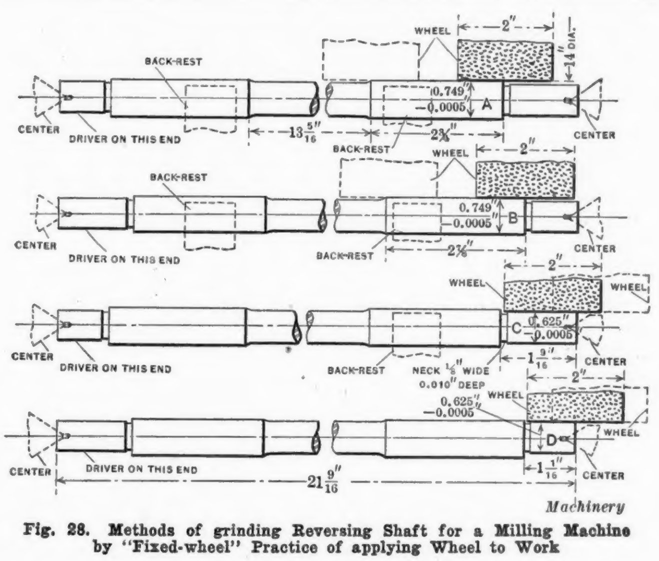


Fig. 28. Methods of grinding Reversing Shaft for a Milling Machine by "Fixed-wheel" Practice of applying Wheel to Work

Work:—Reversing shaft for milling machine, 0.15 to 0.20 per cent carbon machinery steel, not hardened.

Operation:—Grinding four diameters with a Carborundum Co.'s (vitrified) aloxite wheel, grain 365, grade M; 14 inches diameter, 2 inch face; speed, 1637 R. P. M.—6000 feet surface speed; work speed, 210 R. P. M.—35 to 42 feet surface speed; amount removed from diameter 0.015 inch.

Remarks:—"Fixed wheel" method of grinding is used; on diameters (A) and (B), wheel is fed in to stop and traversed four times past work by hand at 10 linear inches per minute for first traverse, 30 linear inches per minute for the last three traverses; 20 pieces per each truing of wheel; grinding time, 2.02 minutes for each end; on diameters (C) and (D), the wheel is fed in to depth and traversed past work four times by hand at the rate of 20 inches per minute; 20 pieces per each truing of wheel; grinding time, 1.69 minute for each end; total time, 7.42 minutes for each shaft; machine used, Landis plain grinding machine.

accomplished in a somewhat similar manner, but in this case it will be noticed that no steadyrests are required on the work. Fig. 28 is another milling machine part that is ground by the "fixed-wheel" method in conjunction with more than two traverses of the work past the wheel. These three examples illustrate practically similar conditions, with the exception of the application of steadyrests to the work.

The gear-box bracket made from an iron casting that is shown in Fig. 27 is another example of the "fixed-wheel" method. It will be noticed in this case that a carborundum wheel, grain 40, grade P, is used. This is rotated at 6000 feet surface speed, whereas work speeds of 52 and 57 feet surface speed are used. The traverse of the wheel past the work varies from 15 to 30 linear inches per minute, the finer traverse being used for roughing and the coarser for finishing. The reason for the finer traverse for roughing is because of the heavy cut taken, whereas for finishing, lighter cuts are used and consequently higher traverse speeds can be employed.

Grinding Cast-iron and Bronze Bushings

There are two methods in use for finishing bushings. Where the wall of the bushing is not very thin, the method generally adopted is to ream the hole and then grind the external diameter, or where reaming is not satisfactory the hole is first ground and then the external diameter ground later by placing the work on a mandrel. Where the wall of the bushing, however, is thin, this method is not satisfactory, especially when the work has been hardened. The reason for this is that the work is liable to distort in hardening, and when gripped in the chuck to grind the internal diameter it is difficult to prevent springing the work. Consequently the hole cannot be ground absolutely true, and driving the work on a mandrel only increases the inaccuracy. The best method of grinding thin wall bushings, as has been previously explained, is to grind the external diameter first by holding the bushing on a floating mandrel and then grind the internal diameter by placing it in a close-fitting sleeve chuck, gripping the work from the ends only and not from the external diameter.

At *A* in Fig. 24 is shown a miter gear sleeve for a milling machine that was ground by the method first mentioned. The hole in this sleeve is reamed to finish size and then it is driven on an arbor and ground. The method of grinding is to feed the wheel in to depth, take one roughing cut, and then traverse the work past the wheel four times to get a finish, at the rate of 15 linear inches per minute for roughing, and 25 linear inches for finishing. In this case, it will also be noticed that the traverse speed is greater for finishing than for roughing because of the heavier roughing cut taken.

Three similar examples of bushing grinding are shown at *A*, *B* and *C* respectively, in Fig. 29. The bushing shown at *A* is made from cast iron and is ground by the "fixed-wheel" method. The bushing shown at *B* is made from tobin bronze and is also ground by the "fixed-wheel" method. For the grinding of the cast-iron bushing at *A* a carborundum wheel is used, whereas for the tobin bronze, an alundum wheel is used. The example shown at *C* is also ground by the "fixed-wheel" method, and for this a corundum wheel is used. In all three cases high work speeds are used, varying from 70 to 136 feet surface speed. From 70 to 80 surface feet is about the best work speed for grinding tobin bronze or phosphor-bronze, whereas the surface speed for cast iron should not exceed 60 to 70 feet when a satisfactory wheel is used.

Examples of Combined "Straight-in" and Traverse Grinding

Fig. 30 shows a pinion shaft made from 0.30 per cent carbon steel, not hardened, that is ground by two methods. The short shoulder *A* is ground by feeding the wheel straight in on the work, whereas the shoulder *B* is ground by stepping the wheel in at intervals along the work and then making several rapid traverses. Advantage here is taken of the use of a wide face wheel, and it will also be noticed that a comparatively low work speed and a coarse grain, medium bond wheel has been used. This example represents good average practice.

The rear axle shown in Fig. 31 presents an interesting method of handling this class of work. For grinding the taper bearing, the grinding wheel is fed in to depth at the end next to the tailstock, then withdrawn and moved over to the other end of the bearing and fed in to depth, after which three traverses of the wheel past the work at 16 linear inches per minute are made. The grinding of this shaft necessitates three separate settings, and for all except operation *B* the wheel is traversed. For this operation the wheel is fed straight in on the work until the final diameter is reached. Another point of interest in connection with the grinding of this part is the special driver. The requirements call for a certain length to be maintained between the taper bearing and the other end of the shaft, and to obviate the extreme care which is necessary to get all the centers of a certain depth the special driver shown is used.

An extremely difficult piece to grind is the spindle shown in Fig. 32. This is made from 0.20 per cent carbon machine steel, not hardened. The work is fairly slender, necessitating, in some cases, a special steadyrest shoe that practically covers the entire surface that is in contact with the wheel where the grinding is being done. The method of grinding this shaft varies on the different shoulders. For grinding shoul-

ders *A* and *D* the wheel is fed straight in on the work until the final diameter is reached, whereas for grinding shoulders *B* and *C* the work is traversed past the wheel. It will be noticed here that the work speed is varied, depending on the manner in which the wheel is presented to the work. Where the wheel is fed directly in on the work, the surface speed varies from 40 to 60 feet, whereas when the work is traversed it varies from 60 to 80 feet. In other words, a slower work speed is used for "straight-in" than for traverse grinding. It will also be noticed that a combination grain

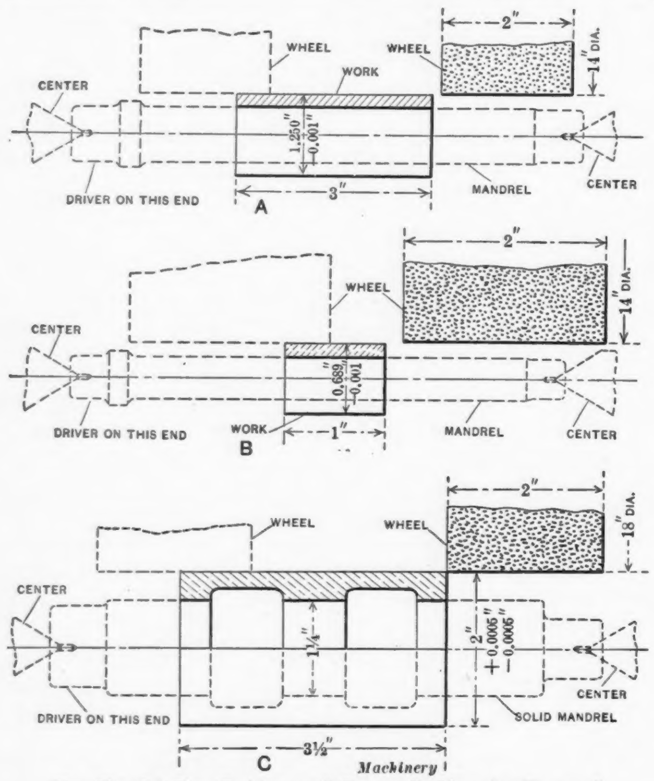


Fig. 29. Grinding Cast-iron and Bronze Bushings by Means of "Fixed-wheel" Method of Grinding

A

Work:—Bushing made from cast iron.

Operation:—Grinding external diameter with a Carborundum Co.'s (vitrified) carborundum wheel, combination grain 46, grade N; 14 inches diameter, 2 inch face; 1728 R. P. M.—6332 feet surface speed; work speed, 416 R. P. M.—136 feet surface speed; amount removed from diameter, 0.025 inch.

Remarks:—"Fixed-wheel" method of grinding is used and work is fed past wheel twice at a table speed of 16 linear inches per minute; 50 pieces turned out to each truing of wheel; production, 100 in 1½ hour; machine used, Brown & Sharpe plain grinding machine.

B

Work:—Bushing made from tobin bronze.

Operation:—Grinding external diameter with a Norton (vitrified) alundum wheel, combination grain 36, grade R; speed, 1728 R. P. M.—6332 feet surface speed; work speed, 416 R. P. M.—75 feet surface speed; amount removed from diameter, 0.020 to 0.025 inch.

Remarks:—"Fixed-wheel" method of grinding is used and two traverses of work past wheel at the rate of 16 linear inches per minute complete operation; wheel trued up once every day; production, 100 pieces in 45 minutes, or about 130 pieces per hour; machine used, Brown & Sharpe plain grinding machine.

C

Work:—Phosphor-bronze bushing.

Operation:—Grinding external diameter with an American (vitrified) corundum wheel, grain 54, grade M; 18 inches diameter, 2 inch face; speed 1241 R. P. M.—6500 feet surface speed; work speed, 134 R. P. M. 70 feet surface speed; amount removed from diameter, 0.020 inch.

Remarks:—"Fixed-wheel" method of grinding used; table traversed at a speed of 20 linear inches per minute; two traverses to complete work; 60 to 80 pieces turned out to each truing of wheel; production, 42 bushings per hour; machine used, No. 12 or 14 Brown & Sharpe plain grinding machine.

corundum wheel rotated at 6000 feet surface speed is used for the job; this is the correct speed for this abrasive wheel.

Miscellaneous Examples of Cylindrical Grinding

The automobile worm drive shaft shown in Fig. 33 is a good example of plain traverse grinding. This part is made from alloy steel, heat-treated, and the grinding is all done by traversing the work by hand.

Fig. 34 shows two special grinding operations; one is the grinding of an upper end of a valve push-rod, and the other a cone for a fan shaft. The upper end of the valve push-rod is made from screw stock and is carbonized and hardened in

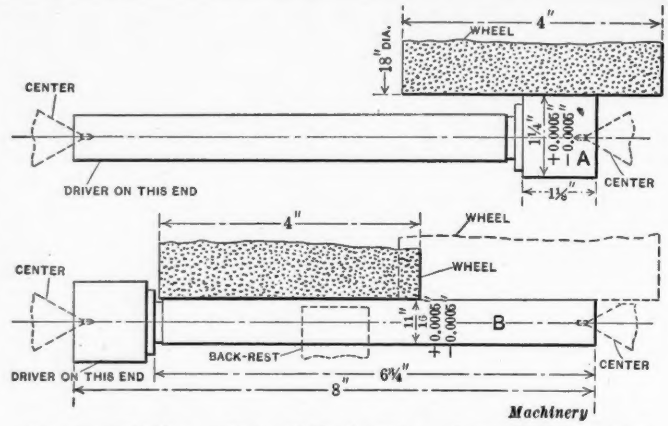


Fig. 30. Finishing a Pinion Shaft by Means of Combined "Step-in," "Straight-in" and Traverse Methods of Grinding

Work:—Pinion shaft, 0.30 per cent carbon steel, not hardened.

Operation:—Grinding two external diameters with a Norton (vitrified) alundum wheel, grain 24, grade M; 18 inches diameter, 4 inch face; speed, 1650 R. P. M.—6050 feet surface speed; work speed, 77 R. P. M.—14 to 25 feet surface speed; amount removed from diameter, 0.020 inch.

Remarks:—"Step-in" method of grinding in conjunction with traverse grinding is used; order of operations is to first feed wheel straight in on diameter (A) and grind to size. Second, reverse work on centers, step-in twice on diameter (B) to within 0.001 inch of finished size, and then traverse the work past the wheel; 50 pieces turned out to each truing of wheel; production, 20 pieces per hour; machine used, 6 by 32 inch Norton plain grinding machine.

oil. The grinding operation consists in finishing the radius on the head of this rod with a fine grain, medium grade alundum wheel. The method of grinding this piece is to first bring the wheel in contact with the work at the shoulder, and then swing the head of the machine around until it stands at right angles to the wheel. The wheel is then fed in on the work again. This procedure is followed until the radius has been ground, bringing the push-rod head to the required diameter.

The cone for the fan shaft shown at *B* in Fig. 34 was

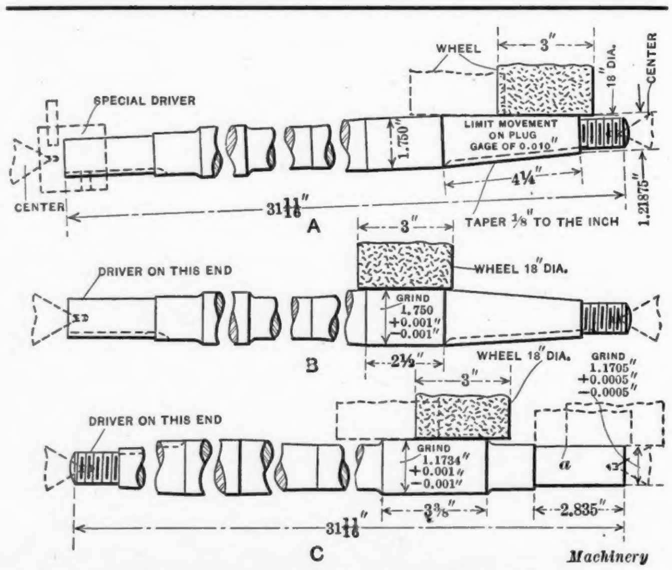


Fig. 31. Grinding a Rear Axle Shaft for an Automobile by Means of "Straight-in" and Traverse Method of Grinding

Work:—Material, Carpenter's "Samson" No. 3 nickel steel, hardened in fish oil, and tempered; allowance of 0.030 to 0.040 inch left on all diameters for grinding; method of grinding is to first feed wheel in almost to depth at the end next the tailstock, then travel over to the other end and feed to depth, and then make three traverses back and forth, using power feed, at the rate of 16 linear inches per minute; grinding limit varies on all diameters (see illustration); operations performed on a 12 by 42 inch Landis plain grinding machine; shaft must strike 60 to 70 hard on scleroscope.

Operation A:—Grinding taper with a Norton (vitrified) alundum wheel, grain 24, grade M; 18 inches diameter, 3 inch face; speed, 1580 R. P. M.—7482 feet surface speed; work speed, 92 R. P. M.—36 feet average surface speed; 16 pieces ground to each truing of wheel.

Operation B:—Grinding main bearing; wheel fed straight in on work; wheel is same grain and grade as above; production on this bearing, one piece in 35 seconds.

Operation C:—Grinding oil retainer fit with a Norton (vitrified) alundum wheel, grain 24, grade L; 18 inches diameter, 3 inch face; operating at same speed as above, but traversed; production time is 1 minute and 31 seconds each. At this same setting the differential bearing (a) is also ground by the same type of wheel, traversed at the rate of 16 inches per minute; time for this operation is 50 seconds.

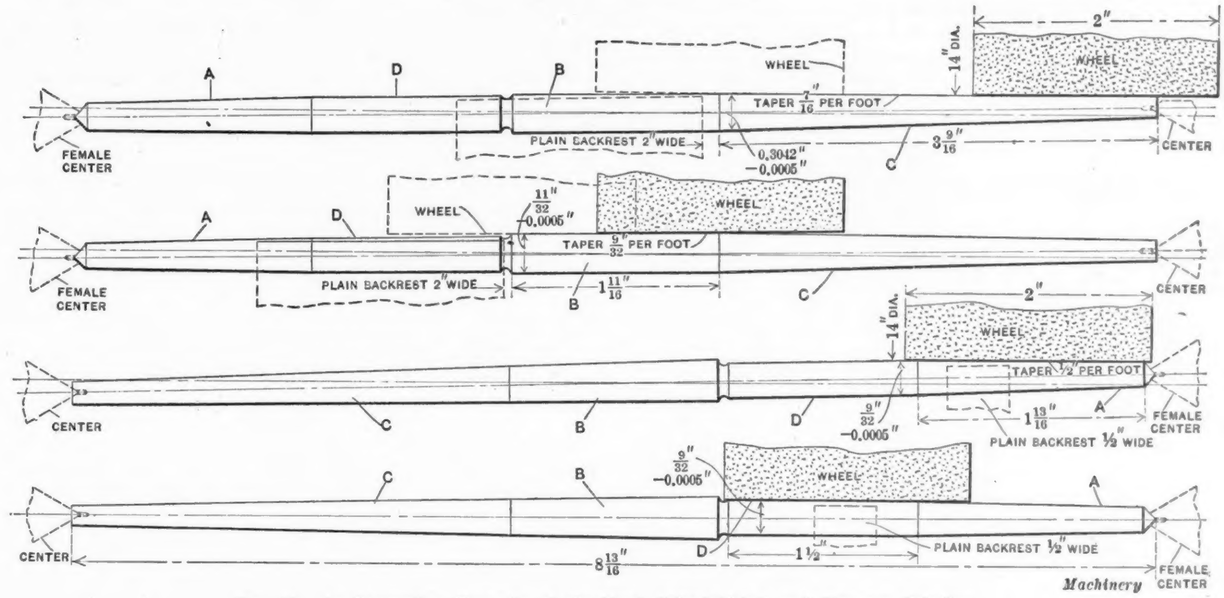


Fig. 32. An Interesting Example of Combined "Straight-in" and Traverse Grinding

Work:—Spindle, 0.20 per cent carbon steel, not hardened.

Operation:—Grinding four diameters, three of which are tapered, with an American (vitrified) corundum combination wheel, grain 58-46, grade K; 14 inches diameter, 2 inch face; speed, 1637 R. P. M.—6000 feet surface speed; work speed, roughing 489 to 733 R. P. M.—40 to 60 feet surface speed; 733 to 978 R. P. M.—60 to 80 feet surface speed for finishing on parts traversed past wheel; amount removed from diameters, 0.010 to 0.015 inch.

Remarks:—Combined straight-in and traverse method of grinding; diameters (A) and (D) are ground by feeding wheel straight in on the work, whereas diameters (B) and (C) are ground by traversing the table; in-feed for straight-in grinding 0.0005 inch per revolution of work; depth of cut for traverse grinding, 0.0005 inch deep per traverse; speed of traverse, 120 inches per minute; three plain back-rests used; shoe, 2 inches wide for parts (B) and (C), and ½ inch wide for parts (A) and (D); actual grinding time on various diameters as follows: (A), 20 seconds; (B), 45 seconds; (C), 20 seconds; (D) 22 seconds; estimated production, 25 completed shafts per hour; machine used, No. 11 Brown & Sharpe plain grinding machine.

taken from a light grinding machine and placed on a Landis plain grinder, using an old type Landis center grinder as a fixture for holding the work. The production was increased in this way from about 500 to 1200 pieces in nine hours, because of the greater rigidity and possibility of taking heavier cuts. The method of grinding this piece is to bring the wheel directly in on the work and then make a couple of rapid traverses to finish. It will be noticed also in this case that a comparatively coarse grain, medium bond wheel is used that is rotated at a surface speed not generally recommended—8272 feet surface speed. In order to get the desired results it is also necessary to increase the work speed, which in this case is above the average, being 115 feet average surface speed.

To Increase Efficiency and Production, Records of all Grinding Jobs should be Kept

The foregoing examples of work are interesting because of the fact that they bring out the various methods adopted for handling work of practically the same character, and also for handling work that differs considerably in shape and nature of material. These examples are also a good indication of the advisability of keeping complete records of all grinding operations so that when a new piece comes along it is not necessary to waste so much time in experimenting. The chart shown in Fig. 35, while gotten up chiefly as a basis for setting piece rates, also contains a number of important points that are valuable from an efficiency standpoint. The example shown in the chart is a gear-box bracket for a milling machine, on which two diameters are to be ground. The method of procedure is carefully outlined. First, the work is put on the mandrel, then placed between the centers, then the headstock of the machine is started revolving. The wheel is then brought into position at the shoulder *A* and fed in to the work to a previously set stop. The wheel is then passed over the work four times without allowing it to run off the end of the work, using hand feed entirely. The first traverse is at 15 linear inches per minute,

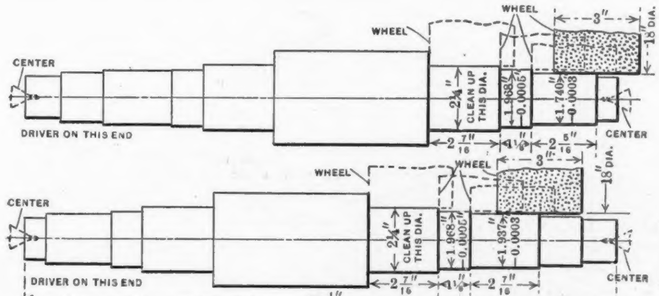


Fig. 33. An Everyday Example of Plain Traverse Grinding

Work:—Automobile worm drive shaft, alloy steel heat-treated.

Operation:—Grinding six diameters with a Norton (vitrified) alundum wheel, grain 46, grade K; 18 inches in diameter, 3 inch face; speed, 1273 R. P. M.—6000 feet surface speed; work speed, 75 R. P. M.—40 feet average surface speed; amount removed from diameter, 0.020 to 0.030 inch.

Remarks: Hand traverse is used for grinding all six diameters; the two diameters on each side of the worm are just cleaned up whereas the other two diameters indicated (see illustration) are ground to within close limits; twelve diameters ground per each truing of wheel; production, 35 shafts complete in 10 hours; machine used, Modern plain grinding machine.

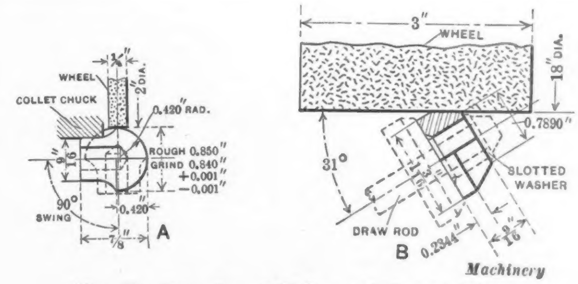


Fig. 34. Examples of Radius and Cone Grinding

A

Work:—Upper end of valve push rod, screw stock, carbonized 0.030 inch deep and hardened in oil; 70 minimum hardness.

Operation:—Grinding radius on head with a Norton (vitrified) alundum wheel, grain 67, grade M; 2 inches diameter, ¼ inch face; speed, 12,800 R. P. M.—6702 feet surface speed; work speed, 320 R. P. M.—70 feet surface speed; amount removed from diameter, 0.010 inch.

Remarks:—Wheel is first brought into contact with work on shoulder, and then head is swung around until it stands at right angles to wheel, which at the same time is fed into work; production, 250 in nine hours; machine used, Rivett universal grinding machine.

B

Work:—Cone for fan shaft, 0.15 per cent carbon open-hearth steel, carbonized 0.030 inch deep and hardened.

Operation:—Grinding cones with a Norton (vitrified) alundum wheel, grain 24, grade M; 18 inches diameter, 3 inch face; speed, 1760 R. P. M.—8272 feet surface speed; work speed, 440 R. P. M.—115 feet average surface speed; amount removed from diameter, 0.010 inch.

Remarks:—An old type Landis center grinder specially fitted up is used for holding work; wheel is fed in directly against work until cleaned up and then traversed to finish; production, 1200 in nine hours; machine used, Landis plain grinding machine.

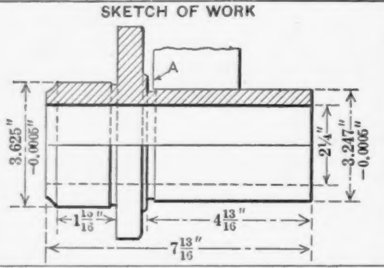
INSTRUCTION SHEET

PART NUMBER 639 p.m. PART NAME Gear-Box Bracket DATE 1/10/15

DEPARTMENT NO. 50 OPERATION Grind two diameters

DO WORK ON Landis Grinding Machine MATERIAL C.I. OPERATION NO. 9 APPROVED S.G.

SKETCH OF WORK



EQUIPMENT REQUIRED

WHEEL: Carborundum; Grain 40, Grade P, Face 2½" wide

MANDREL: 2¼" diameter

GRINDING DOG: to fit mandrel.

MICROMETER: Four-inch.

	ORDER OF OPERATIONS	WHEEL SPEED R.P.M.	WHEEL SPEED S.F	WORK SPEED R.P.M.	WORK SPEED S.F.	FEED INCHES PER REV.	FEED INCHES PER MIN.	ST'D TIME, MIN.
	1st Setting: Grind long end. { Limits 0.0005"							
	{ Finish No.2							
1.	Put work on mandrel							0.54
2.	Place between centers							0 25
3.	Start headstock revolving							0.10
4.	Bring wheel into position at shoulder "A" in sketch							
	and feed wheel into work to stop. Pass wheel							
	over work 4 times without allowing wheel to							
	run off end of work. Use hand feed entirely							
	1st traverse, feed not over 15" per minute	1273	6000	60	52	0.25	15	
	Last 3 traverses, feed about 30" per minute			"	"	0.50	30	2.68
	Move wheel back							
5.	Stop headstock and micrometer work							0.23
6.	Remove work from between centers							0.25
7.	Remove mandrel from work							0.52
	Allowance for dressing wheel, 4 minutes on each 10 pieces							0.40
								4.87
							10%	.49
								5.36
	2nd Setting: Grind short end. { Limits 0.0005"							
	{ Finish No.2							
	Order of operations, speeds, and feeds the same	1273	6000	60	57	0.25	15	
	as for 1st Setting			"	"	0.50	30	3.67
							10%	0.37
								4.04
	Allowance for rest, 6 minutes on every hour							0.94

TOTAL STANDARD TIME 10.4

TIME ALLOWANCE FOR SETTING MACHINE 40 min. RATE BASIS 20 ¢ per hour PREMIUM TIME 14.8

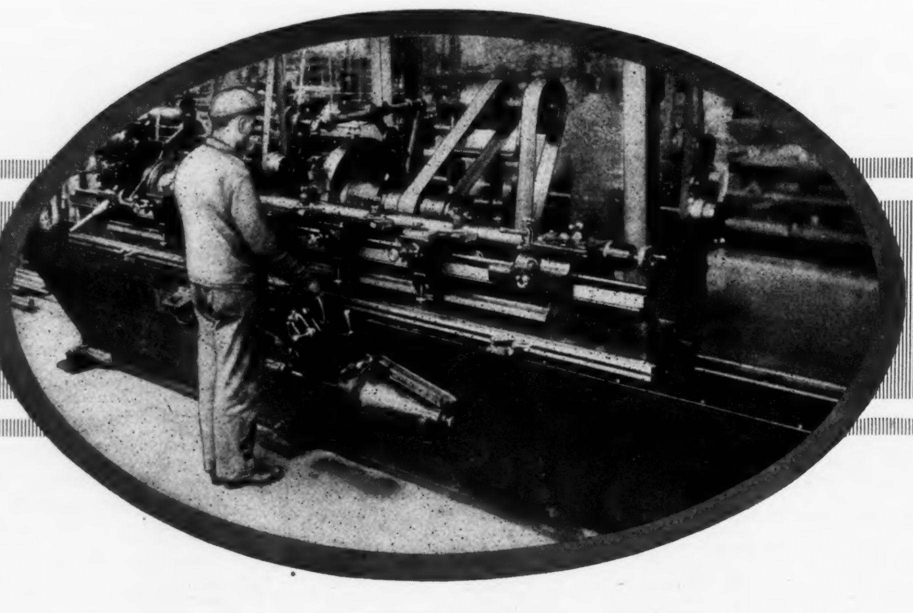
Machinery

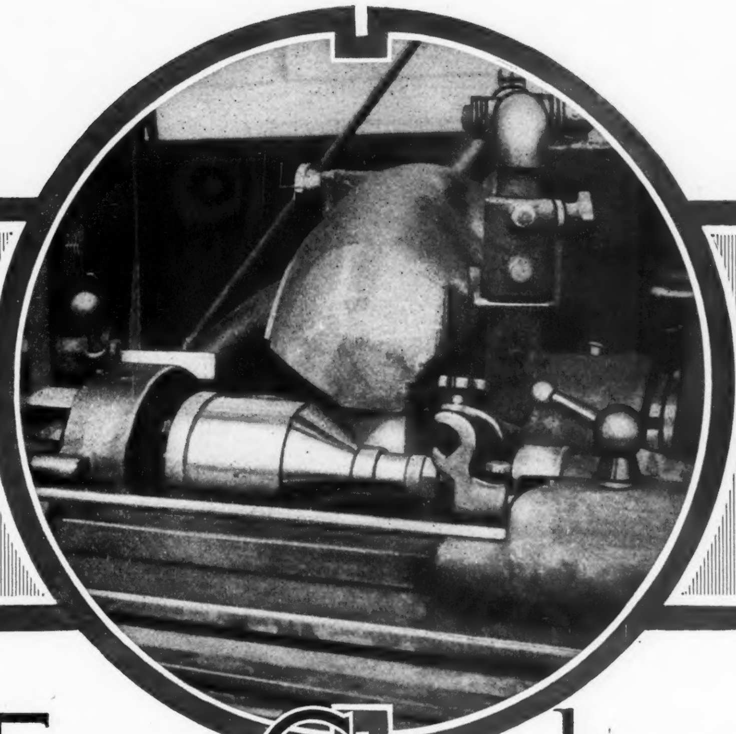
Fig. 35. Chart showing Method of keeping Complete Record of Grinding Data

and the last three traverses at double this speed, or 30 inches per minute. The wheel is then moved back from the work, the headstock is stopped, and the work measured. If ground to the size which it should be if the stop has been properly set, the work is then removed from the center and taken from the mandrel, when the operations on that particular shoulder are finished. Allowances are then made for dressing the wheel as well as making necessary adjustments of the machine, and for a resting period. Of course at the rate set forth here, it would be impossible for an operator to keep it up all day long, and a certain allowance is made for a rest every hour. In this case it is six minutes. By studying this chart, it will be seen that practically every factor has been taken into consideration, and when a piece rate price is based on a study of this character it is possible to get the cost down to about what it should be. In order to increase production, a premium rate is also given, so that there is always an incentive to turn out more work. A careful study of each job that comes up is recommended, because of the more satisfactory work that results, and the increase in production.

Summary

The examples of work shown in the foregoing have not been chosen in all cases because they represent the best practice, but have been selected to illustrate the points that it is necessary to observe in grinding cylindrical work successfully. The examples shown illustrate work that is turned out on a manufacturing basis, and are not of the tool-room variety. The reason for this is that for several years the development of the grinding machine has been along the line of increasing production, at the same time retaining the necessary accuracy. In the section on work and wheel speeds, it will be noticed that the work speeds given are considerably lower than those generally used on tool-room work. For tool-room work, as a rule, high work speeds with fine grain, hard bond wheels are used. These wheels, in order to reduce the pressure on the work, are usually trued off so that only a small portion of the wheel surface contacts with the work. This method of procedure is not recommended for regular manufacturing work, because the greatest production is only possible when the full face of the wheel is used. In this article, an endeavor has been made, in most cases, to explain the reason for points that seem to be at variance with the best practice. As has been pointed out, the method used depends upon a number of varying factors, such as, the machine used, the character of the work, and the wheels, as well as the opinion of the operator.





Form Grinding

THE term "form grinding," as applied to the manufacture of machine and automobile parts, is generally used to refer to the production of both straight and irregular-shaped surfaces. On cylindrical grinding it is used to indicate that the wheel is fed straight in on the work without any traverse of the wheel or work. In an endeavor to differentiate between form grinding of straight and irregular surfaces, other names for the grinding of plain surfaces have been suggested, such as straight-in grinding, wide-wheel grinding, etc. As a matter of fact, however, in practice the term "form grinding" is used to indicate the production of both straight and irregular shaped surfaces on cylindrical work where the work or wheel is not traversed. There are also many other applications of the formed wheel method of grinding, such as surface grinding, grinding splined shafts, crankshafts, etc. These various subjects, with the exception of grinding splined shafts, will be taken up separately in another article.

Development of Form Grinding

Comparatively little is known as to the first use of a form grinding wheel for producing irregular or straight shaped surfaces. It has been stated that the Singer Sewing Machine Co. about ten years ago used a straight-in cut method of grinding small shafts for sewing machines, and about six years ago the Norton Grinding Co. produced a special index wheel to be used in connection with truing the grinding wheel for grinding multiple diameter shafts. It is definitely known, however, that form grinding first came into prominent use in the grinding of multiple-throw crankshafts for automobile engines. The chief reason for using a wide wheel and feeding it straight in on the work in the grinding of crankshafts was that the length of the bearings and space between the crankpin cheeks was so short that a very limited traverse could be used. This made the operation of grinding crankpins and bearings both slow and expensive. Heavy, rigid grinding machines were then built to carry wide face wheels, and instead of using the grinding machine for finishing only, crankshafts were ground complete on the bearings and crankpins from the rough forgings. This advance, of course, greatly increased production, with a consequent reduction in the manufacturing costs.

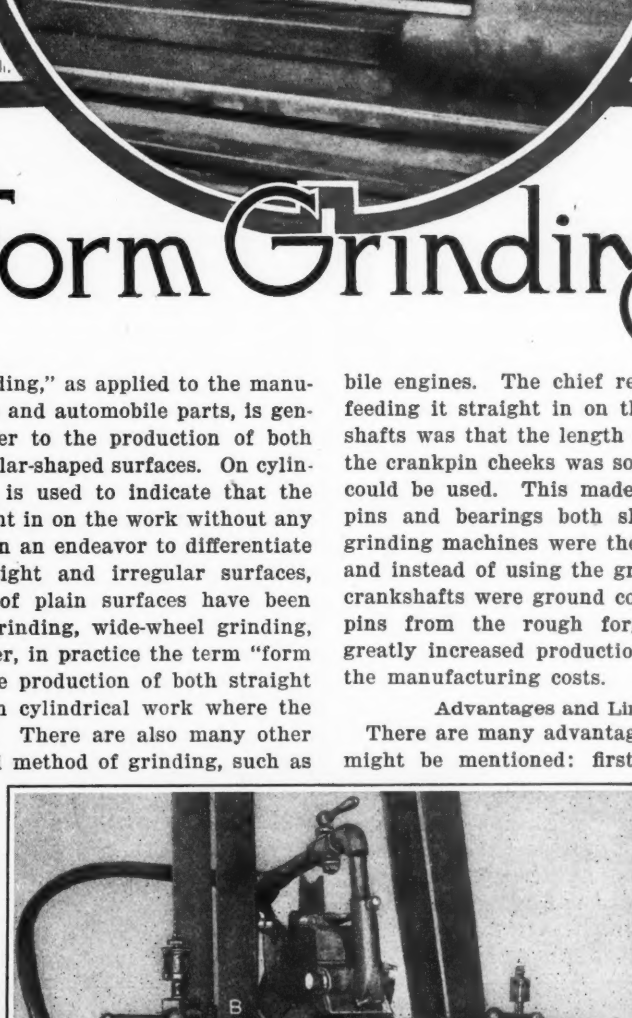


Fig. 36. Brown & Sharpe Plain Grinding Machine equipped with Special Automatic In-feeding Device for Form Grinding

Advantages and Limitations of Form Grinding

There are many advantages of form grinding, among which might be mentioned: first, greater production; second, accurately finishing hardened parts of irregular shape; third, grinding from the rough; fourth, increasing possibilities of securing interchangeable parts.

Greater production is possible because of the fact that a wide wheel carries a greater number of cutting particles that come in contact with the work than a narrower wheel, and consequently removes a greater amount of material in a given time. The wide wheel also, in covering the length of the part being ground, produces the same amount of work in a given time as several narrower wheels. To illustrate, a 1-inch face wheel only covers one-tenth the surface covered by a 10-inch face wheel, and assuming that other conditions are the same, will only produce one-tenth as much work as the wider wheel.

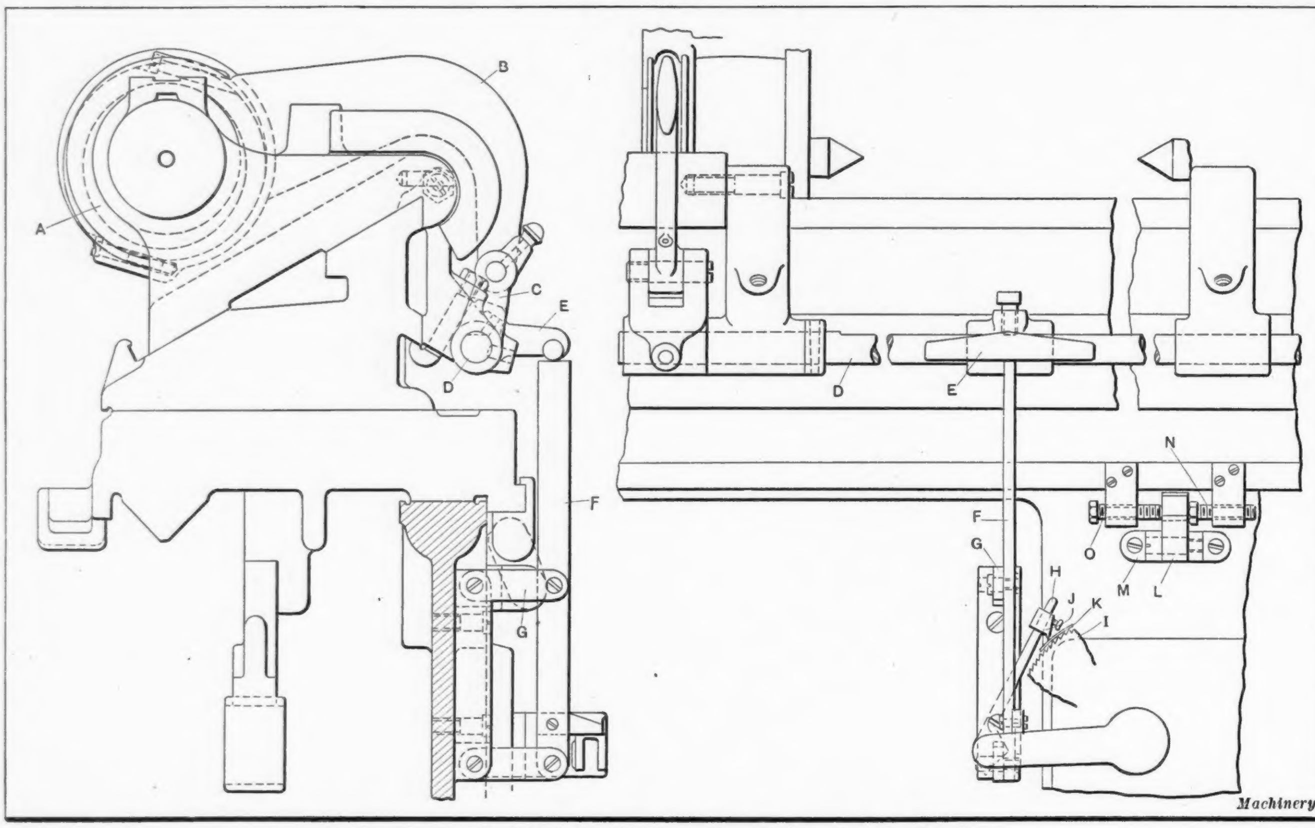


Fig. 37. Details of In-feeding Device used on Machine shown in Fig. 36

The use of the form wheels presents the only practical means of accurately finishing flat or cylindrical shaped irregular surfaces, and this advantage alone is of considerable importance. As has been previously mentioned, form grinding has made possible the grinding of crankshafts, etc., from the rough, and to a certain extent, is responsible for the great reduction in the cost of automobiles within the last few years.

An advantage of form grinding that is worthy of special note is its possibility of producing interchangeable parts. With a wide face wheel that is kept in good condition by being trued frequently with a diamond, it is a comparatively easy task to secure accurate work. The wheel is fed straight in on the work to the pre-determined point, and allowed to dwell on the work until no sparks show. In this way, parts can be ground with comparative ease to limits of 0.0005 inch.

The width of face of grinding wheels used for form grinding has gradually increased until today we find wheels up to 10 and 12 inches face being used with success. The chief limitations of form grinding are the difficulties encountered in making the grinding wheel and in producing a machine of the necessary strength and rigidity. Another limitation is in the depth of form. This can be such that the peripheral speed of the various diameters on the wheel produces a different cutting action, making the production of very deep forms impracticable. A difference of 2 inches on the diameter of the wheel, however, easily comes within the possibilities of the grain and grade that can be furnishd by the wheel manufacturers. Again, wheels for form grinding must be trued up more frequently than is necessary in traverse grinding, but this is not a serious disadvantage. In fact, grinding authorities state that on work which must be held within close limits a generous use of the diamond not only increases production, but also insures greater accuracy of product. Different degrees of finish on the work can be produced by truing the wheel so that it will be sharp or smooth. This makes it possible in some cases to use the same wheel for roughing and finishing.

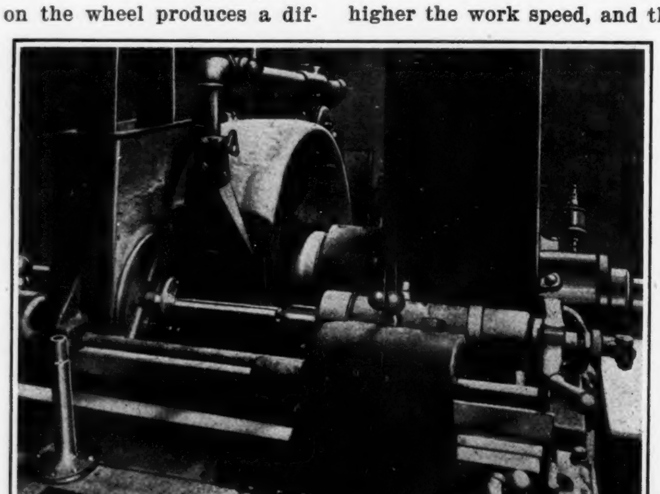


Fig. 38. Set-up on a Special-purpose Norton Plain Grinding Machine for form-grinding a Ford Transmission Shaft

A form grinding wheel, to stand up satisfactorily, should be provided with liberal fillets and sharp corners avoided. It is also impossible to do under-cutting with a grinding wheel, and where possible the work should be designed with these two points in view if form grinding is to be done. The grinding machine also calls for considerable study if satisfactory results are to be obtained. In the first place, it should be rigidly and accurately constructed so that it will stand up under the strains of the work which it is called upon to perform. The spindles should also be made of the finest kind of material, with ample bearing surfaces and large well made boxes of good material. Vibration in the machine should be reduced to a minimum.

Work Speeds for Form Grinding Mild Steel

For form grinding soft steel containing from 0.15 to 0.25 per cent carbon, the work speed should be in the neighborhood of from 30 to 55 feet surface speed, and is dependent upon the wheel used, and to a certain extent upon the finish desired. The harder the bond of the wheel as a rule, the higher the work speed, and the softer the bond, the lower the work speed. For form grinding 0.15 to 0.25 per cent carbon steel which has been casehardened, the work speeds are just about the same, but the wheels are generally of a harder bond and slightly finer grain than those used for soft steel. The examples shown in the following can be used as a general guide for the selection of the proper wheels and work speeds for different classes of work.

Work Speeds for Form Grinding Chrome-Nickel and Chrome-Vanadium Steels—Heat-treated

In the grinding of alloy steels which have been heat-treated, the work speeds seldom exceed 55 feet surface speed.

As a general rule, grinding wheels of combination grain are used for form grinding alloy steels, and it has been found that wheels of, say, No. 24 combination work best at surface speeds ranging from 25 to 40 feet. The harder the bond of the wheel, of course, the higher must be the surface speed to get the same results, but on form grinding, hard bond wheels of fine grain are not recommended because of the liability to glaze and heat up quickly. Of course the speed of the work is dependent to a certain extent upon its diameter, small-diameter work being rotated at a higher surface speed than large-diameter work. In the examples shown in Figs. 39, 40, 44, and 48, it will be noticed that the surface speeds range all the way from 39 to 55 feet, the average being about 45 to 50 feet.

Rate of In-feed of Wheel for Form Grinding

The rate at which the wheel is fed in on the work for form grinding varies all the way from 0.0005 to 0.003 inch per revolution of the work, the rate of in-feed depending on the slenderness of the work and the manner in which it is supported, also to some extent on the rigidity of the machine in which the operation is being accomplished. This in-feeding of the wheel on the work is generally done by hand, but several devices have been designed for doing this by power. Of course the hand feed method offers more latitude, as far as increasing production is concerned, than the power feed, but can only be done successfully by an experienced operator.

An interesting in-feeding device which has been adapted to the Brown & Sharpe plain grinding machine for form grind-

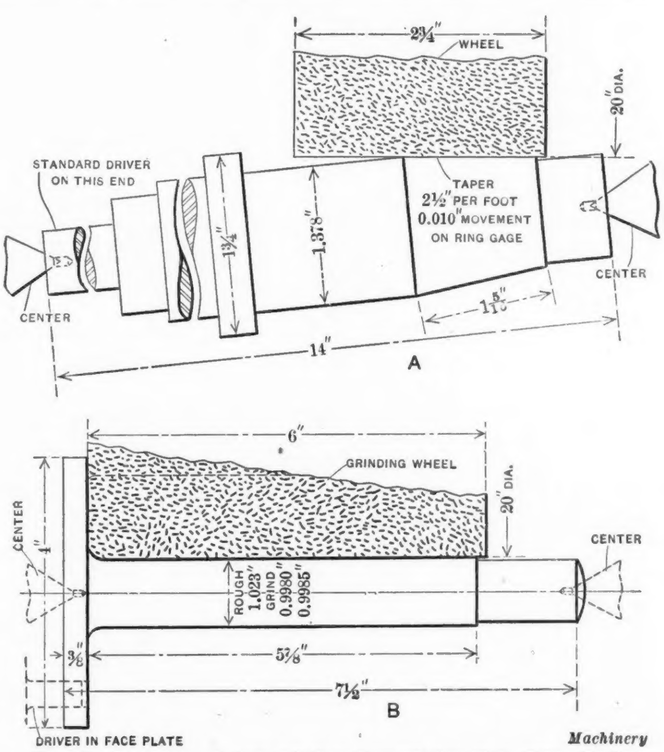


Fig. 39. Examples of form-grinding Transmission Main Drive Shafts

A

Work:—Transmission main drive shaft, 0.20 per cent carbon open-hearth steel, carbonized and hardened.

Operation:—Straight-in grinding taper with a Norton (vitrified) alundum combination wheel, grain 38-24, grade L; 20 inches diameter, 2¾ inch face; 1146 R. P. M.—6000 feet surface speed; work speed, 200 R. P. M.—70 feet average surface speed; amount removed from diameter, 0.015 to 0.025 inch.

Remarks:—Wide-face wheel is fed straight in on work, not traversed, and work-table is set off to the correct taper; production, 325 pieces in nine hours; machine used, 10 by 36 inch Norton plain grinding machine.

B

Work:—Transmission shaft, 0.20 to 0.25 per cent carbon, 0.018 per cent vanadium alloy steel drop-forging, heat-treated.

Operation:—Straight-in grinding shank with a Norton (vitrified) alundum combination wheel, grain 38-24, grade L; 20 inches diameter, 6 inch face; speed, 1146 R. P. M.—6000 feet surface speed; work speed, 150 R. P. M.—39 feet surface speed; amount removed from diameter, 0.025 inch.

Remarks:—Wide-face wheel is fed straight in on work, not traversed; 65 pieces turned out to each truing of wheel; production, 550 pieces in eight hours; machine used, 10 by 24 inch Norton special-purpose plain grinding machine.

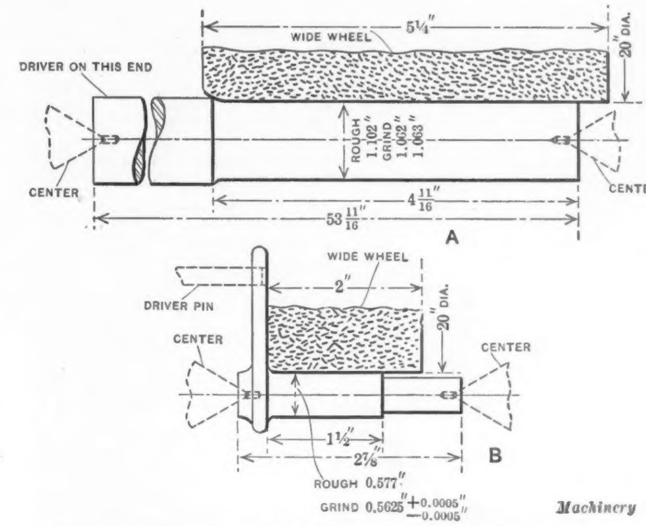


Fig. 40. Two Interesting Examples of "Straight-in" Grinding—Automobile Drive Shaft and Automobile Spring Shackle

A

Work:—Automobile drive shaft, 0.20 per cent carbon, chrome-nickel vanadium, hot-rolled steel bar, heat-treated.

Operation:—Straight-in grinding plain bearing with a Norton (vitrified) alundum combination wheel, grain 38-24, grade L; 20 inches diameter, 5¼ inch face; 1146 R. P. M.—6000 feet surface speed; work speed, 200 R. P. M.—55 feet surface speed; amount removed from diameter, 0.030 to 0.040 inch.

Remarks:—Wide-face wheel is fed straight in on work, not traversed; 60 pieces turned out to each truing of wheel; production, 375 pieces in eight hours; machine used, 10 by 50 inch, Norton special-purpose plain grinding machine.

B

Work:—Automobile spring shackle, 0.20 per cent carbon, 0.18 per cent vanadium drop-forging, heat-treated.

Operation:—Straight-in grinding shank with a Norton (vitrified) alundum wheel, grain 46, grade O; 20 inches diameter, 2 inch face; 1146 R. P. M.—6000 feet surface speed; work speed, 480 R. P. M.—71 feet surface speed; amount removed from diameter, 0.012 to 0.015 inch.

Remarks:—Wide-face wheel is fed straight in on work, not traversed; 22 pieces turned out to each truing of wheel; production, 1400 pieces in eight hours; machine used, 6 by 32 inch Norton plain grinding machine.

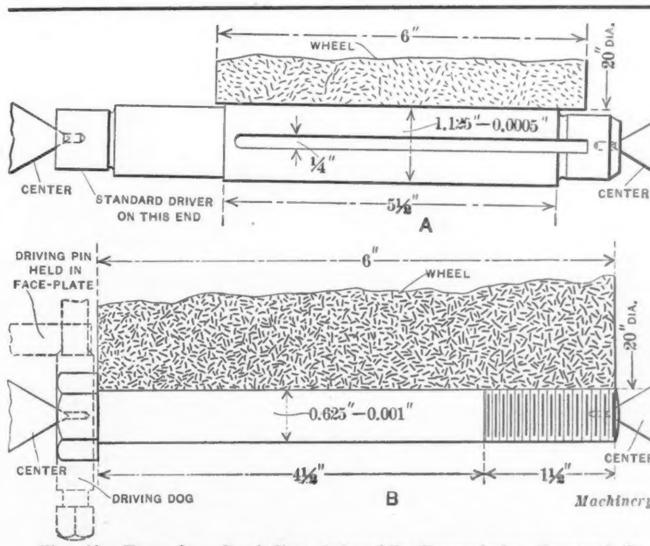


Fig. 41. Examples of grinding Automobile Transmission Countershaft and Automobile Front Axle Spindle Bolt by Form Wheel Method

A

Work:—Transmission countershaft, 0.20 per cent carbon open-hearth steel, carbonized and hardened.

Operation:—Straight-in grinding external diameter with a Norton (vitrified) alundum combination wheel, grain 38-24, grade L; 20 inches diameter, 6 inch face; speed, 1241 R. P. M.—6500 feet surface speed; work speed, 100 R. P. M.—30 feet surface speed; amount removed from diameter, 0.015 to 0.025 inch.

Remarks:—Wide-face wheel is fed straight in on work, not traversed; 50 pieces turned out to each truing of wheel; production, 330 pieces in nine hours; machine used, 10 by 36 inch Norton plain grinding machine.

B

Work:—Front axle spindle bolt, 0.20 per cent carbon open-hearth steel, carbonized and hardened.

Operation:—Straight-in grinding external plain surface and threaded section with a Norton (vitrified) alundum combination wheel, grain 38-24, grade L; 20 inches diameter, 6 inch face; speed, 1241 R. P. M.—6500 feet surface speed; work speed, 200 R. P. M.—33 feet surface speed; amount removed from diameter, 0.015 to 0.025 inch.

Remarks:—Wide-face wheel is fed straight in on work, not traversed; 50 pieces turned out to each truing of wheel; production, 480 pieces in nine hours; machine used, 10 by 36 inch Norton plain grinding machine.

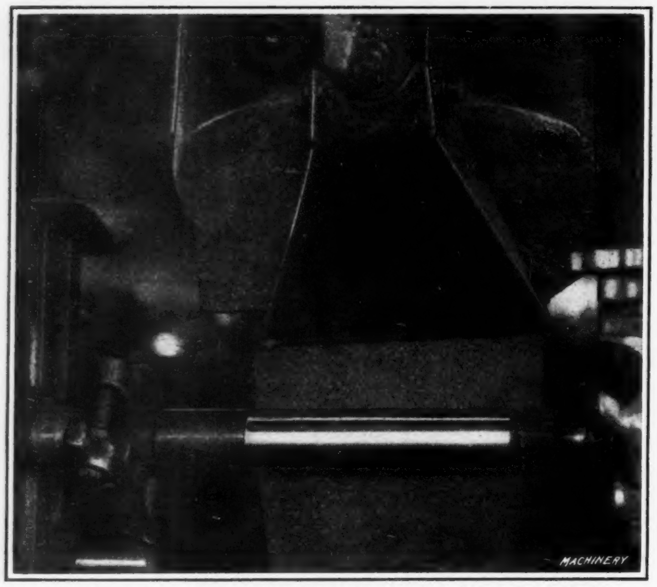


Fig. 42. Set-up for grinding Transmission Countershaft in Norton Plain Grinding Machine

ing is shown in Figs. 36 and 37. This device is operated as follows: An eccentric *A* held on the work head spindle oscillates a shaft *D* through lever *B* and connection *C*. Shaft *D* carries an adjustable shoe *E* which can be moved along it to contact with lever *F*. This lever is fulcrumed in bracket *G* and on its lower end carries a ratchet pawl lever *H*. Ratchet pawl *H*, in turn, carries a pawl *J*, which engages with a feeding dial *I* fastened to the same shaft that carries the handwheel for operating the in-feed of the grinding wheel slide.

As the work head revolves, pawl *J* moves the feeding dial *I* around two notches, or in other words brings the grinding wheel in at the rate of 0.002 inch per revolution of the work. This continues until the correct diameter has been reached, when the automatic kick-out comes into play. This consists of a segment shield *K* fastened to the feeding dial and adjustable around its circumference. This, as shown in Fig. 37, passes beneath the pawl, raising it and preventing any further action upon the ratchet dial. The grinding wheel is then allowed to dwell on the work until no sparks show, and

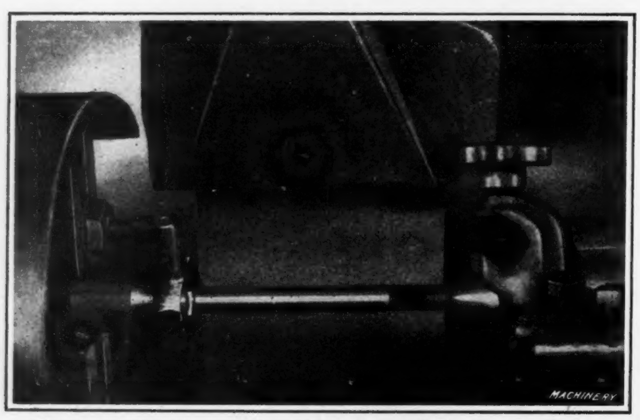


Fig. 43. Set-up for grinding Front Axle Spindle Bolt in Norton Plain Grinding Machine

in this way very accurate dimensions can be obtained. In fact, the limits on the particular piece on which this device was used were 0.0005 inch on the diameter. Feeding the wheel in on the work by power feed has an advantage over the hand feed, inasmuch as no feeding is done if the belt driving the work spindle slips. When an operator is feeding the wheel in by hand, care must be taken to see that the work runs smoothly, or else flats will be produced on the work. Of course, if the wheel is allowed to dwell at the end of the cut these flats will in most cases be eliminated.

Form Grinding Transmission Shafts

The finishing of transmission shafts for automobiles is a good example of the advantages to be gained by the use of wide wheels, fed straight in on the work. Fig. 38 illustrates a special-purpose Norton plain grinding machine set up for this work in the plant of the Ford Motor Co. This shaft is brought directly from the lathe turning operation, and is finished complete at the rate of 550 in eight hours, to limits of 0.0005 inch on the diameter. As is shown at *B* in Fig. 39, a No. 24, combination grain No. 38 alundum wheel is used for the job, which is 6 inches face, 20 inches diameter. *A* in Fig. 39 shows a transmission main drive shaft on which a taper bearing is being ground. In this case, the same grain

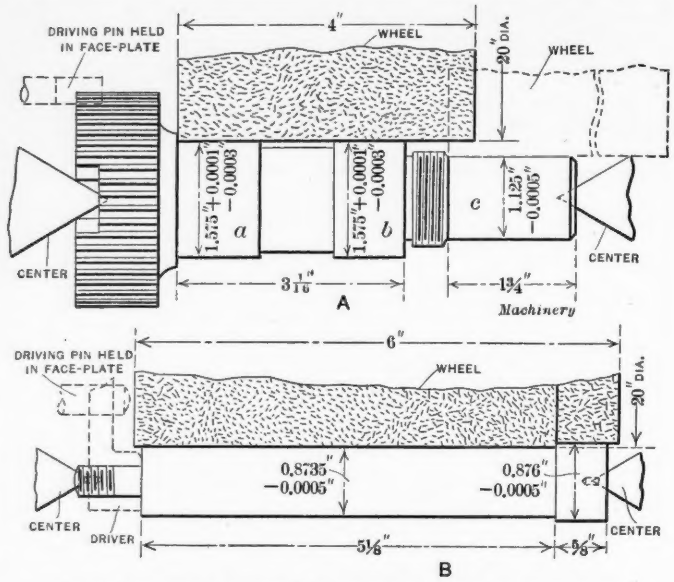


Fig. 44. Examples of grinding Idler Gear and Main Drive Gear Shaft by Form Wheel Method

A

Work:—Main drive gear, 0.20 per cent carbon alloy steel, carbonized and heat-treated.

Operation:—Straight-in grinding external diameter with a Norton (vitrified) alundum combination wheel, grain 38-24, grade L; 20 inches diameter, 4 inch face; speed, 1241 R. P. M.—6500 feet surface speed; work speed, about 100 R. P. M.—41 feet surface speed; amount removed from diameter, 0.010 inch.

Remarks:—Wide-face wheel is fed straight in on portions (a) and (b), not traversed; small end (c) is also ground in same setting by shifting wheel; production, 265 pieces in nine hours; machine used, 10 by 36 inch Norton plain grinding machine.

B

Work:—Idler gear shaft, 0.20 per cent carbon open-hearth steel, carbonized and hardened.

Operation:—Straight-in grinding two external diameters with a Norton (vitrified) alundum combination wheel, grain 38-24, grade L; 20 inches diameter, 6 inch face; speed, 1241 R. P. M.—6500 feet surface speed; work speed, 100 R. P. M.—24 feet surface speed; amount removed from diameter 0.015 to 0.025 inch.

Remarks:—Wide-face wheel is fed straight in on work, not traversed; 50 pieces turned out to each truing of wheel; production, 375 pieces in nine hours; machine used, 10 by 36 inch Norton plain grinding machine.

and grade of wheel is used, but the work speed is much higher. While this piece has an over-all length almost twice that of *B*, the production is not anywhere nearly as great. This is largely due to the time spent in keeping the wheel face true, and probably is due to the pace set by the operator.

The automobile drive shaft shown at *A* in Fig. 40 is

Fig. 45. Set-up for grinding Main Drive Gear on Norton Plain Grinding Machine

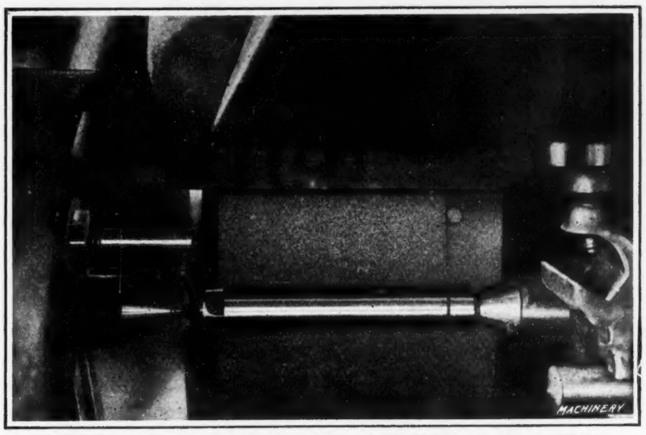


Fig. 46. Set-up for grinding Idler Gear Shaft by Form Wheel Method—Note Method of Driving

another good example of "straight-in" grinding. In this case a wheel 5¼ inches wide is used and the work is finished to a limit of 0.001 inch on the diameter. The same grade and grain of wheel is used as in Fig. 39, but the work speed has been slightly increased over that shown at *B*. This increase in speed, however, is not beyond the limits of the grain and grade of the wheel used. The automobile spring shackle shown at *B* in Fig. 40 illustrates one point previously stated regarding the work speed. In this case it will be noticed that an alundum wheel, grain 46, grade O, is used, and the surface speed is 71 feet. Here it will be noticed that the grain is much finer than for example *A* and the bond is also harder.

Form Grinding Automobile Transmission Countershaft and Spindle Bolt

Fig. 41 shows two interesting examples of form grinding. One is a transmission countershaft which is made from 0.20 per cent carbon open-hearth steel, carbonized and hardened, and the other is a front axle spindle bolt made from the same material. Figs. 42 and 43, respectively, show how these pieces are handled in the grinding machine. Referring to Fig. 42, it will be noticed that the transmission countershaft is held on

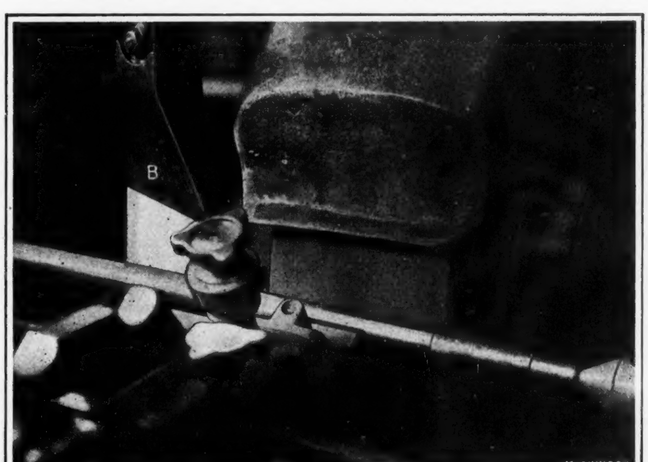


Fig. 47. Grinding a Ford Rear Axle in Norton Special-purpose Plain Grinding Machine

the centers and driven in the ordinary manner by a dog, as is also the case with the front axle spindle bolt shown in Fig. 43.

Grinding Automobile Gear Shafts

Two examples of form grinding on automobile parts are shown in Fig. 44. *A* is a main drive gear shaft on which three diameters are finished by means of feeding the wheel straight in on the work without any lateral traverse. Diameters *a* and *b* are finished at the same time, whereas diameter *c* is finished by moving the work over, and is done in the same setting as diameters *a* and *b*. The manner in which this gear shaft is handled is shown in Fig. 45. Here it will be seen that a driver which contacts with the teeth in the gear takes the place of the ordinary driving dog. The idler gear shaft shown at *B* is a little more difficult to grind. This is provided with two diameters and the difference between these two diameters is only 0.0025 inch, necessitating very careful truing of the grinding wheel. To accomplish this, the grinding machine is provided with stops so that the wheel truing device can be brought to the proper position each time for truing the wheel. The centers in the work are also center-reamed to the same depth, so as to bring the work in the correct relation to the wheel. Fig. 46 shows the method by which this piece is handled. A small driver screwed onto the end of this piece acts as a dog to drive the work on the centers.

Form Grinding a Rear Axle Shaft

The rear axle shaft shown in Fig. 48 is a good example of the straight-in method of grinding. Referring to this illustration, it will be seen that three diameters are ground by feeding the wheel straight in on the work. For one diameter, a wheel 6½-inch face is used, for another a 6-inch face wheel,

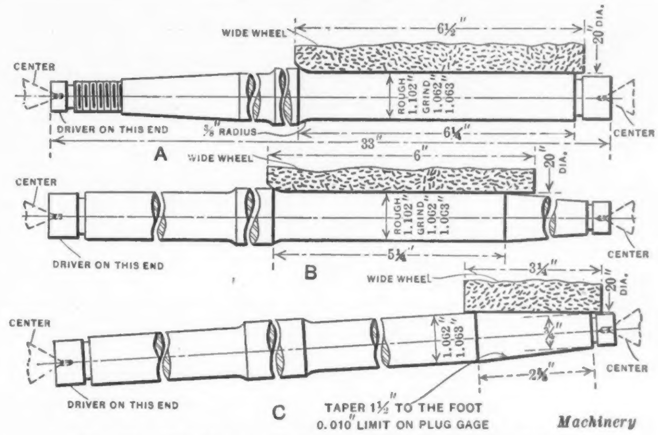


Fig. 48. Finishing a Ford Rear Axle Shaft Complete by Form Wheel Method

Work:—Rear axle shaft, 0.20 per cent carbon, 0.18 per cent vanadium alloy steel bar hot-rolled and heat-treated; allowance 0.030 to 0.040 inch left on all diameters for grinding; wheel fed straight in on work without traverse; wheel allowed to dwell at end of cut until practically no sparks show; grinding limit 0.001 inch on straight portions of shaft; three operations on a 10 by 36 inch Norton special-purpose plain grinding machine.

Operation A:—Wheel, Norton (vitrified) alundum combination, grain 38-24, grade L; 20 inches diameter, 6½ inch face; speed, 1146 R. P. M.—6000 feet surface speed; work speed, 200 R. P. M.—55 feet surface speed; 60 pieces turned out to each truing of wheel; production, 350 pieces in eight hours.

Operation B:—Wheel, same as above; same data also applies to wheel speed, work speed, production, etc.

Operation C:—Wheel, Norton (vitrified) alundum combination, grain 38-24, grade L; 20 inches diameter, 3¼ inch face; speed, 1146 R. P. M.—6000 feet surface speed; work speed, 200 R. P. M.—51 feet average surface speed; 60 pieces turned out per each truing of wheel; production, 450 pieces in eight hours.

and for the third or tapered end a wheel 3¼ inches face is used. On this work three Norton special-purpose plain grinding machines are used. Fig. 47 shows how the work is supported while operation *B* is being performed. Here, it will be seen that a Norton rigid steadyrest of the type shown in Fig. 5 is used, carrying a hardened steel work-shoe. In order to grind this bearing absolutely true, knob *A* for operating the steadyrest shoe is adjusted to spring the work against the wheel just as it is being finished to the required diameter. Another interesting point about this job is the type of water

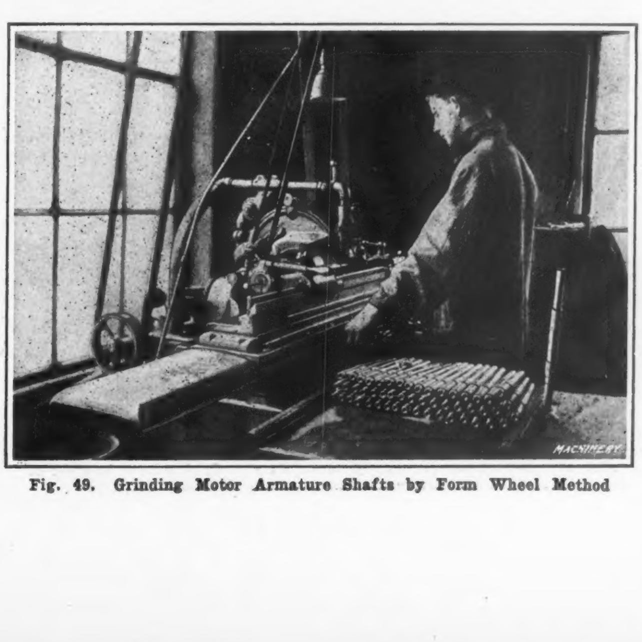


Fig. 49. Grinding Motor Armature Shafts by Form Wheel Method

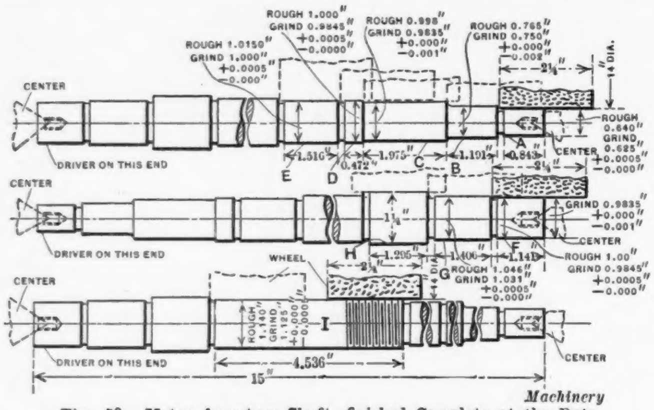


Fig. 50. Motor Armature Shaft, finished Complete at the Rate of 105 in Ten Hours

Work:—Armature shaft, 0.15 to 0.25 per cent carbon machine steel; ground after rough-turning operations when soft; allowance of 0.015 inch on all diameters for grinding except one; wheel fed straight in on work without traverse at the rate of about 0.002 inch per revolution of work; wheel allowed to dwell at end of cut until no sparks show; grinding limit varies on all diameters from 0.0005 to 0.002 inch; eight form grinding operations, one traverse operation; performed on a 6 by 32 inch Norton plain grinding machine; shafts carried through in lots of 500; one shoulder finished on each shaft at one time; production, about 105 finished shafts in ten hours.

Operations A to E inclusive:—Wheel, Norton (vitrified) alundum, 2¼ inches wide, 14 inches diameter; grain 24, grade N; speed, 1500 R. P. M.—5500 feet surface speed; trued with diamond every 75 shoulders ground; work speed, 350 R. P. M.—58 to 92 feet surface speed.

Operations F to H inclusive:—Wheel, same as above; same data also applies to wheel speed; work speed, 350 R. P. M.—90 to 115 feet surface speed; for operation (F) wheel is trued 0.001 inch taper.

Operation I:—Wheel, same as that used for operations (A) to (H) inclusive; same data also applies to wheel speed; work speed, 350 R. P. M.—104 feet surface speed; 0.032 inch removed from diameter; time, one minute for each shaft; wheel traversed.

spout used. In this case it will be noticed that a special water spout made from sheet metal has been slipped over the regular spout. This spout *B* is made fan-shaped and throws a stream of cutting lubricant across the entire width of face of the grinding wheel. The stream of cutting lubricant directed by this spout is also "thin," thus reducing splashing.

Grinding Motor Armature Shafts

The motor armature shaft shown in Fig. 50 is another good example of straight-in grinding. In this case the wheel used is not wide as compared with the other examples that have been shown. This 2¼-inch face wheel, however, covers all the shoulders on the shaft except shoulder *I* which is 4.536 inches long. The method by which this particular example is ground is shown in Fig. 49. The operator takes a batch of about 100 shafts, and grinds one shoulder at a time on all the shafts; then he shifts the position of the work table in relation to the wheel and grinds the second shoulder, and so on until all the shoulders except *I* have been finished; for this shoulder the work is traversed past the wheel. It will also be noticed that shoulder *F* is ground with a slight taper, and for grinding this, it is necessary to true the wheel to a corresponding taper.

Grinding Electric Starter Shafts

The electric starter shaft shown in Fig. 52 is another example which illustrates the advantages of form grinding on shafts of the multi-shoulder variety. This particular electric starter shaft is made from cold-rolled steel, and has five diameters that are ground by feeding the wheel straight in on the work. Three of the diameters require separate settings for each operation, whereas two diameters are ground by forming the wheel to cover both dimensions at the same time. In this way five operations are performed on four machines, and the product from each machine is 100 shafts per hour. As shown in Fig. 37, for performing operation *D*, Fig. 52, a stop is provided on the machine for locating the wheel in the correct relation to the work. This comprises a block *L* fulcrumed in bracket *M* which can be swung down out of the way when truing the grinding wheel by means of the device shown on the machine in Fig. 51. The work is then relocated by moving block *L* into place between the two set-screws *N* and *O*. As shown in Fig. 51, the diamond truing device consists of two rods *A* and *B* which are held in the holder in an angular position, so as to bring their two forward ends about 1½ inch apart. The plungers holding the diamonds are operated by micrometer screws so that each diamond point is independently adjustable.

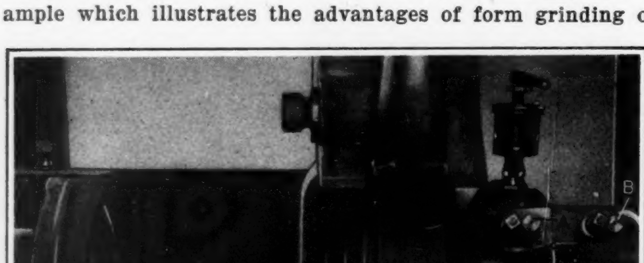


Fig. 51. Set-up for grinding Electric Starter Shafts by "Straight-in" Method on Brown & Sharpe Plain Grinding Machine

Advantages of Form Method of Grinding on Miscellaneous Machine Parts

The example of straight-in grinding shown in Fig. 53 is an excellent illustration of the advantage of straight-in over traverse grinding. When this particular part was ground by the traverse method, the time for 100 pieces was seven hours, thirty minutes. By bringing the wheel straight in on the work, the time was cut down on 100 pieces to two hours,

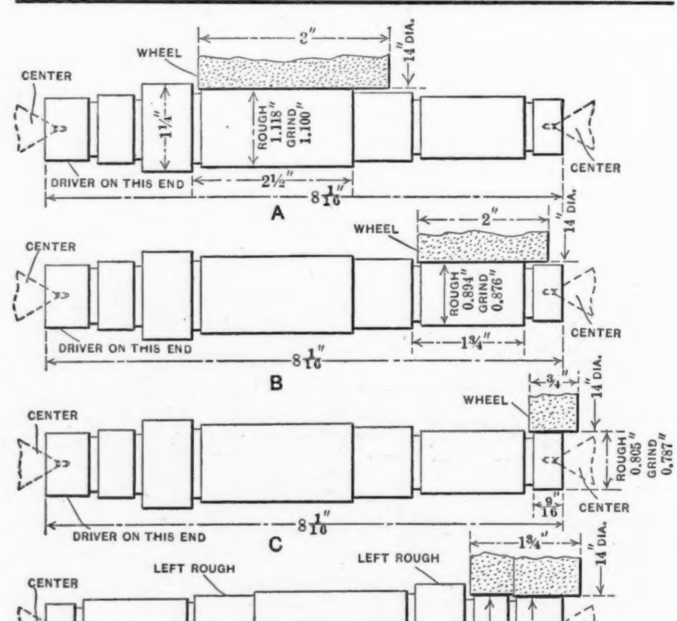


Fig. 52. Electric Starter Shaft, finished Complete at the Rate of 100 Shafts per Hour on Four Brown & Sharpe Plain Grinding Machines

Work:—Electric starter shaft, cold-rolled steel; ground after rough-turning operation when soft; allowance of 0.018 inch left on all diameters for grinding; wheel fed straight in on work without traverse; in-feed, 0.002 inch per revolution of work; wheel allowed to dwell at end of cut until practically no sparks show; grinding limit, 0.00025 inch on all diameters; five operations performed on four B. & S. plain grinding machines; output, 100 shafts per hour from each machine.

Operation A:—Wheel, Norton (vitrified) alundum, 3 inches by 14 inches, combination grain 38-36, grade L; speed, 1450 R. P. M.—5314 feet surface speed; trued with diamond for every 80 shafts ground; work speed, 188 R. P. M.—54 feet surface speed.

Operation B:—Wheel, Norton (vitrified) alundum, 2 inches by 14 inches, combination grain 38-36, grade L; speed, 1450 R. P. M.—5314 feet surface speed; trued with diamond after every 80 shafts ground; work speed, 188 R. P. M.—44 feet surface speed.

Operation C:—Wheel, Norton (vitrified) alundum, ¾ by 14 inches, combination grain 38-36, grade L; speed 1450 R. P. M.—5314 feet surface speed; work speed, 188 R. P. M.—40 feet surface speed.

Operation D:—Wheel, Norton (vitrified) alundum, 1¾ inch by 14 inches, combination grain 38-46, grade K; speed, 1450 R. P. M.—5314 feet surface speed; trued after every 80 shafts with special diamond truing device carrying two diamonds; work speed, 188 R. P. M.—43 feet average surface speed.

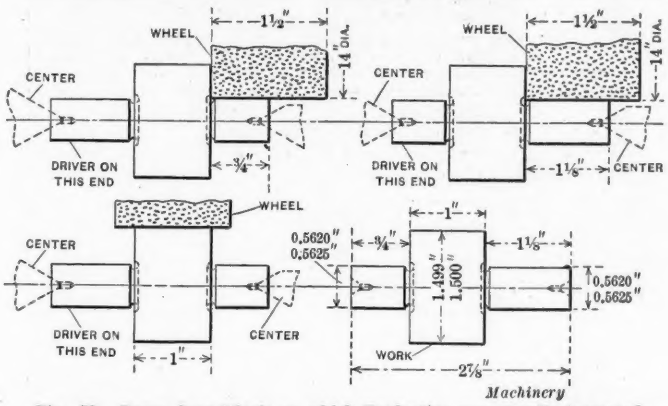


Fig. 53. Pump Gear Blank on which Production was greatly increased by using "Straight-in" Grinding in preference to the Traverse Method

Work:—Pump gear blank, 0.30 per cent carbon steel, not hardened.

Operation:—Straight-in grinding three diameters with an American (vitrified) corundum wheel, combination grain 58-46, grade L; 14 inches diameter, 1½ inch face; speed, 1773 R. P. M.—6500 feet surface speed; work speed, small diameters, 441 R. P. M.—65 feet surface speed; amount removed from diameter, 0.015 inch.

Remarks:—Wide face wheel is fed straight in on work without lateral traverse at the rate of 0.0005 inch per revolution of the work; 100 pieces turned out to each truing of wheel; work put through in lots of 100 pieces; production, 100 pieces in two hours, eighteen minutes; machine used, No. 11 Brown & Sharpe plain grinding machine.

eighteen minutes without sacrificing accuracy or finish of work. The cast-iron drive pinion shown at *B* in Fig. 54 is another example which illustrates the advantage of straight-in grinding over traversing the wheel. On a lot of 100 pieces, the previous time by the traversing method was seven hours, forty-eight minutes. This time was practically cut in two by bringing the wheel straight in on the work, the grinding then being accomplished in four hours, thirty minutes. The example *A* in Fig. 54 shows a little closer time between the traversing and straight-in methods of grinding. On forty pieces the time required for traversing the wheel was twenty-six minutes, twenty-six seconds, and by bringing the wheel straight in on the work the time for forty pieces was twenty-one minutes, twelve seconds—a gain of about five minutes. The reason that the straight-in method shows such a slight advantage in this case is because of the slenderness of the work and the care with which it has to be handled. The gain, however, is sufficient to warrant the use of the straight-in method of grinding in preference to traversing the work.

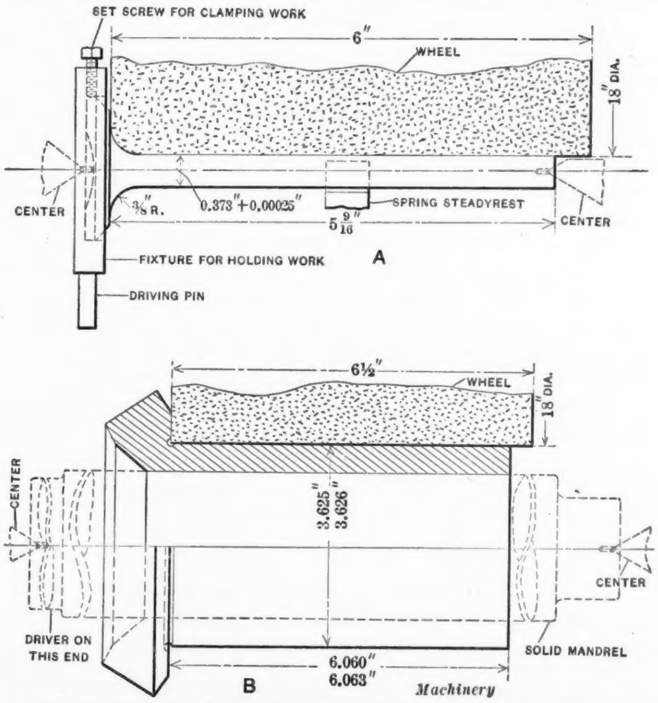


Fig. 54. Two Interesting Examples of the "Straight-in" Method of Grinding—one showing up the Limitations and the other the Advantages of this Method

A

Work:—Gas engine valve stem, 0.30 per cent carbon steel, not hardened.

Operation:—"Straight-in" grinding diameter of stem with a Norton (alundum) wheel, grain 38-46, grade J; 18 inches diameter, 6 inch face; speed, 1379 R. P. M.—6500 feet surface speed; work speed, 255 R. P. M.—25 feet surface speed; amount removed from diameter, 0.010 to 0.012 inch.

Remarks:—Wide face wheel is fed straight in on work without any lateral traverse, at the rate of 0.0005 inch per revolution of the work; 50 pieces turned out to each truing of wheel; production, 40 pieces in twenty-one minutes, twelve seconds; machine used, No. 12 Brown & Sharpe plain grinding machine.

B

Work:—Drive pinion made of cast iron.

Operation:—"Straight-in" grinding stem of pinion with a Norton (vitrified) crystolon wheel; grain 50, grade L; 18 inches diameter, 6½ inch face; speed 1379 R. P. M.—6500 feet surface speed; work speed, 79 R. P. M. —75 feet surface speed; amount removed from diameter 0.015 inch.

Remarks:—Wide face wheel is fed straight in on work without any lateral traverse at the rate of 0.0005 inch per revolution of the work; 10 pieces turned out to each truing of wheel; production, 100 pieces in four and one-half hours; parts put through in lots of 100 pieces; machine used, No. 16 Brown & Sharpe plain grinding machine.

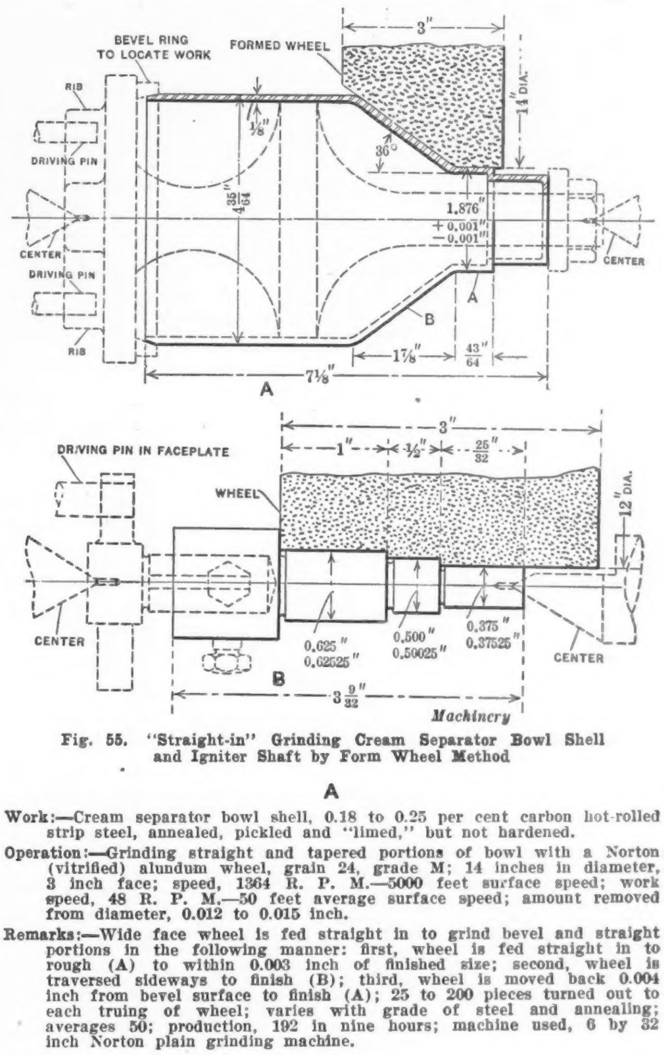


Fig. 55. "Straight-in" Grinding Cream Separator Bowl Shell and Igniter Shaft by Form Wheel Method

A

Work:—Cream separator bowl shell, 0.18 to 0.25 per cent carbon hot-rolled strip steel, annealed, pickled and "limed," but not hardened.

Operation:—Grinding straight and tapered portions of bowl with a Norton (vitrified) alundum wheel, grain 24, grade M; 14 inches in diameter, 3 inch face; speed, 1364 R. P. M.—5000 feet surface speed; work speed, 48 R. P. M.—50 feet average surface speed; amount removed from diameter, 0.012 to 0.015 inch.

Remarks:—Wide face wheel is fed straight in to grind bevel and straight portions in the following manner: first, wheel is fed straight in to rough (A) to within 0.003 inch of finished size; second, wheel is traversed sideways to finish (B); third, wheel is moved back 0.004 inch from bevel surface to finish (A); 25 to 200 pieces turned out to each truing of wheel; varies with grade of steel and annealing; averages 50; production, 192 in nine hours; machine used, 6 by 32 inch Norton plain grinding machine.

B

Work:—Igniter shaft, 0.20 per cent carbon steel, not hardened.

Operation:—"Straight in" grinding three external diameters with a Norton (alundum) wheel, grain 38-46, grade K; 12 inches diameter, 3 inch face; speed, 2069 R. P. M.—6500 feet surface speed; work speed, 306 R. P. M.—40 feet average surface speed; amount removed from diameter, 0.010 inch.

Remarks:—Wide face wheel is fed straight in on work without lateral traverse; actual grinding time—one man mounting work, one man operating machine—43 minutes for 100 shafts; work put through in lots of 100 pieces; machine used, No. 11 Brown & Sharpe plain grinding machine.

The example of straight-in grinding shown at *B* in Fig. 55 brings up a point in regard to operating the machine that has not previously been mentioned. On account of the shape of this particular part, it is necessary to use a special driver which must be held in place by set-screws, as shown. This takes some time to put in place, and two methods were adopted for operating the machine. One was to have one man mounting the work and operating the machine, and by this method the time for 100 pieces was fifty-three minutes. By having two men, one helper and one machine operator, the time on 100 pieces was cut down to forty-three minutes. For truing up the grinding wheel, a special truing device

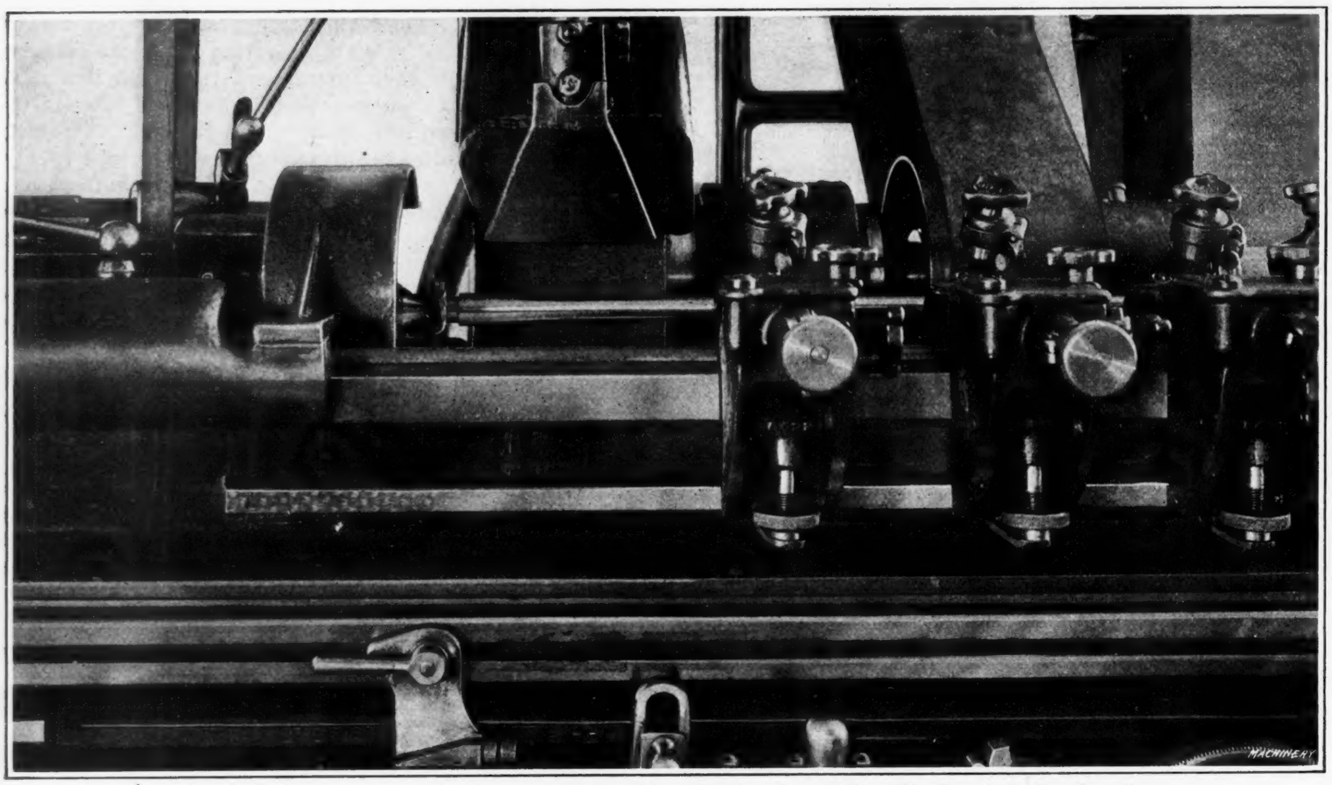


Fig. 56. Set-up on a 10 by 36 Inch Norton Plain Grinding Machine for grinding Rifle Barrels in One Operation

holding three diamond holders was used, so that all three diameters on the wheel could be trued up at the same setting.

Grinding a Cream Separator Bowl Shell

The cream separator bowl shell shown at *A* in Fig. 55 illustrates an example of work for which the form wheel method of grinding is particularly adapted. In this case, a tapered and straight shoulder has to be finished and the method of accomplishing this is to first feed the wheel straight in to rough diameter *A* to within about 0.003 inch of the finished size. Then the work is moved sidewise so as to finish bevel surface *B*. The work is again moved back from the wheel about 0.004 inch, whereupon the wheel is fed straight in to finish surface *A* and at the same time take a light finishing cut from surface *B*. In this way, both surfaces are finished accurately at the rate of 192 pieces in nine hours.

Grinding Rifle Barrels

The grinding of rifle barrels in large quantities has necessitated devising special equipment and means for handling the work expeditiously. It is no exception, therefore, to find that the wide face grinding wheel has been adapted with success to this work. Fig. 56 shows a Norton 10 by 36 inch plain grinding machine set up and in operation on rifle barrel grinding. This particular rifle barrel, shown in Fig. 57, is over 26 inches long, and is practically ground for its entire length. The barrel is ground taper from the muzzle up to within a short distance of the breech end and terminates in a 10-inch radius. The wheel used for this purpose is 5 inches face, 20 inches in diameter, and is trued with a 10-inch radius for about one-half its face width, the remaining part of the face being trued straight. The swivel table of the machine is set off to the required taper.

This particular rifle barrel is made from an unannealed forging of from 0.45 to 0.50 per cent carbon. Usually it is ground after the bore of the barrel has been reamed, and in some cases slugs are inserted in the ends instead of having the centers fit directly in the bore. On this particular barrel the external diameter is finished by the power and hand traverse methods. The taper portion of the barrel is ground by traversing the work past the wheel by power, whereas the radius portion is finished by hand. The operator, as soon as he finishes the taper, brings the work slowly up against the radius on the wheel and finishes this portion of the barrel to shape and size. On an average, thirty-five to forty barrels can be turned out between each truing of the wheel, but the straight portion of the wheel requires to be trued up about twice for every truing up of the radius section. The truing, however, is done by taking a very light cut with the diamond from the face of the wheel, and does not alter the diameters on the wheel perceptibly. The rate at which the work is traversed past the wheel varies to a considerable extent, but the usual practice is to take light cuts with coarse traverse feeds, practically the full width of the wheel being used per revolution of the work for roughing. Three standard Norton rigid steadyrests located from 8 to 10 inches apart are used for supporting the work. These steadyrests carry hardened and ground steel shoes which are finished to the same taper as that on the barrel.

Another interesting example of rifle barrel grinding is shown in Fig. 58. As will be seen by referring to this illustration, this rifle barrel is handled in an entirely different manner. Instead of traversing the wheel along the work straight from the radius section to the muzzle, the wheel is stepped in at intervals along the diameter of the work, the reason for this being that the taper on the barrel is not continuous but changes at five points. To complete the barrel requires five operations and five Norton 10 by 36 inch plain grinding machines, which are fitted up with special attachments for this work. For performing

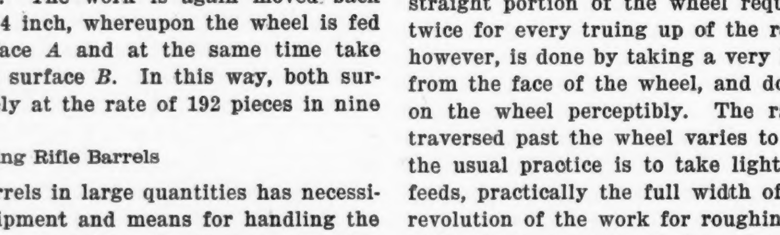


Fig. 57. Example illustrating One-operation Method of grinding Rifle Barrels

Work:—Rifle barrel, 0.45 to 0.50 per cent carbon unannealed steel forgings.

Operation:—Grinding taper and radius with a Norton (vitrified) combination wheel, grain 38-36, grade K; 20 inches diameter, 5 inch face; speed, 1184 R. P. M.—6200 feet surface speed; work speed, 150 R. P. M.—35 feet average surface speed; amount removed from diameter, 0.015 to 0.020 inch.

Remarks:—Power traverse is used for grinding taper, and upon completion of this section, work is fed slowly by hand against wheel to finish radius; 35 to 40 barrels to each truing of wheel; three rigid steadyrests used 8 to 10 inches apart; production, 20 completed rifle barrels per hour; machine used, 10 by 36 inch Norton plain grinding machine.

operation *A*, the machine is provided with a headstock locating attachment which fits over the locating block on the left-hand end of the table, so that the headstock can be brought up until the center engages with the center hole in the locating attachment. The locating block for the headstock is common to all of the five machines used for this work. This device is provided for relocating the headstock after the center has been ground, which is necessary because of the wear that takes place. As is shown in Fig. 58, operation *A* consists in spotting the barrel in the center, and the locating block on the swivel table is placed properly for locating the steadyrest to support the work at this point. The table is located by a pin at the front of the base which engages with a slot in a block attached to the sliding table. In this way the rifle barrel is always in the correct position relative to the grinding wheel for spotting the center of the barrel.

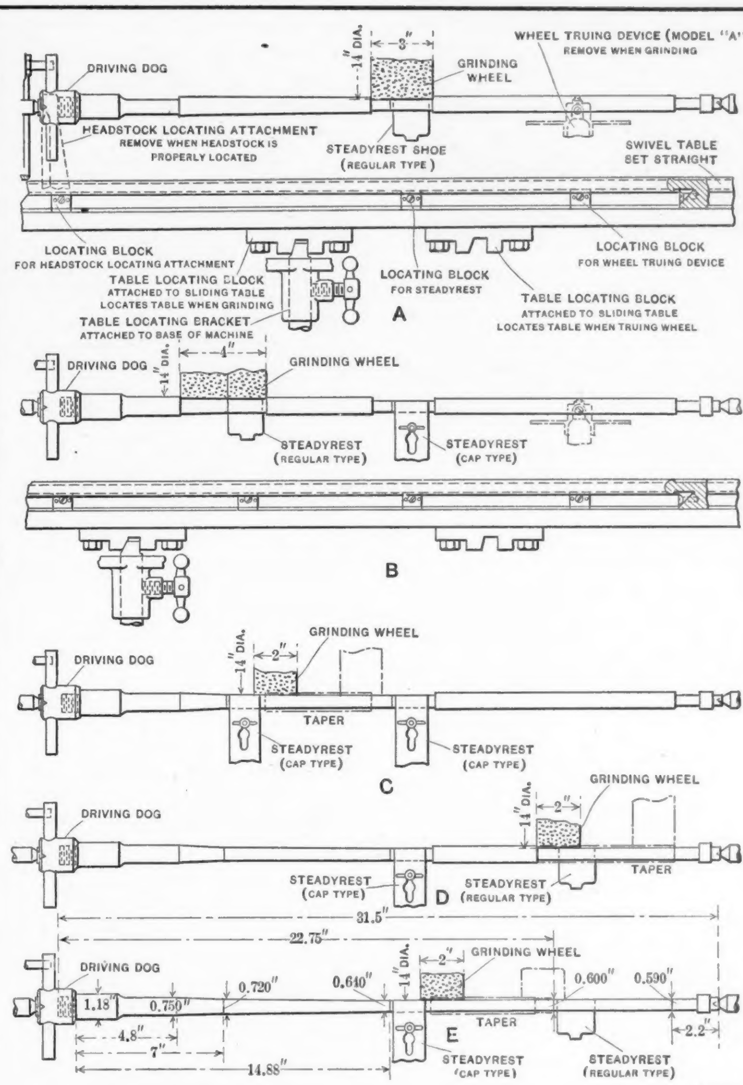


Fig. 58. Example illustrating Five-operation Method of grinding Rifle Barrels

Work:—Rifle barrel, 0.45 to 0.50 per cent carbon unannealed steel forgings.

Operation A:—Spotting center of barrel for steadyrest shoe and finishing terminal points of two tapers with a Norton (vitrified) alundum wheel, grain 38-36, grade J or K; 14 inches diameter, 3 inch face; speed, 1637 R. P. M.—6000 feet surface speed; work speed, 150 R. P. M.—25 feet average surface speed; amount removed from diameter, 0.012 to 0.015 inch.

Operation B:—Spotting for steadyrest shoe and finishing barrel to size at terminus of two tapers near breech end of barrel with a Norton (vitrified) alundum wheel, grain 38-36, grade J or K; 14 inches diameter, 4 inch face; operating at same speed as for operation (A); work speed also the same.

Operation C:—Traverse grinding portion of barrel located between points spotted in operations (A) and (B) with a Norton (vitrified) alundum combination wheel, grain 24, grade J or K; 14 inches diameter, 12 inch face; wheel and work speeds the same as for operation (B).

Operation D:—Traverse grinding taper near muzzle of barrel with a Norton (vitrified) alundum combination wheel; grain 24, grade J or K; wheel and work speed same as for operation (B).

Operation E:—Traverse grinding taper portion located midway between muzzle and center of barrel with the same shape and brand of wheel as used for operation (D); wheel and work speeds same as for operation (B).

Remarks:—Five Norton 10 by 36 inch plain grinding machines are required with one operator for each machine; each of the five operations requires practically the same time; production is at the rate of 35 per hour from each machine.

The second locating block on the sliding table shown to the right of the one just mentioned, is used for locating the table when the wheel truing device is being used. For operation *A*, the swivel table is set in the correct position for grinding straight work, and the former on the truing device is provided with the necessary double taper so as to produce the correct shape on the face of the 3-inch wheel. After the first barrel has been ground, the micrometer stops on the steadyrests and the positive stops on the cross-feed mechanism are properly set to obtain the correct diameter on the barrel. These are left in this position until it is necessary to adjust them as the wheel wears down. The shoes used in the steadyrests are made from hardened steel and are ground to fit the shape of the barrel at the points where they contact with it.

Operation *B* consists in spotting the barrel by the use of a 4-inch face wheel close to the breech end. For supporting the barrel for this operation, a cap-type steadyrest is placed on the table in the correct position by means of a locating block, and the shoe of this rest engages that portion of the barrel that has already been ground. A regular type solid steadyrest is placed on the table directly in front of the point where operation *B* is being accomplished, to give additional support to the work. A locating pin engaging with the table locating block is attached to the sliding table, and correctly locates the work with reference to the grinding wheel for this operation, as was the case in operation *A*. The wheel truing device in this case also has two tapers so as to produce the correct shape on the face of the grinding wheel. When performing this operation, the swivel table is set, as before, for grinding straight work, the wheel being trued to the correct taper.

Operation *C*, as shown in Fig. 58, consists in traversing the work past a 2-inch face wheel. For this operation, the table is set off to the required taper, and two cap-type steadyrests are located as indicated, for supporting the work. In this operation, the two tapers produced by the form wheels in operations *A* and *B* are matched up. The wheel is trued by using the table traverse, the diamond being held in a holder attached to the footstock of the machine.

Operation *D* is also a traverse grinding operation, and the headstock is located in the same manner as for operation *A*. A cap-type steadyrest is used at the center of the barrel and is located by the block on the swivel table. A regular type steadyrest is placed to the right of the cap-type steadyrest, and is also located in the correct position by means of a locating block. The swivel table is set off to the correct taper, and a 2-inch face grinding wheel is used. The power traverse is used for this traverse grinding operation. The grinding wheel is trued by means of a diamond carried in the holder on the footstock of the machine.

Operation *E* is performed in a somewhat similar manner to operation *D*, and is the final operation on the barrel. By referring to Fig. 58, it will be noted that every provision has been made for the rapid operation of the grinding machine so that the operator can more fully apply his attention to the turning out of the work. The production from each machine is figured on a basis of thirty-five rifle barrels per hour, giving a total of about 350 completed rifle barrels in ten hours from five machines. For grinding this barrel it will also be noted that full advan-

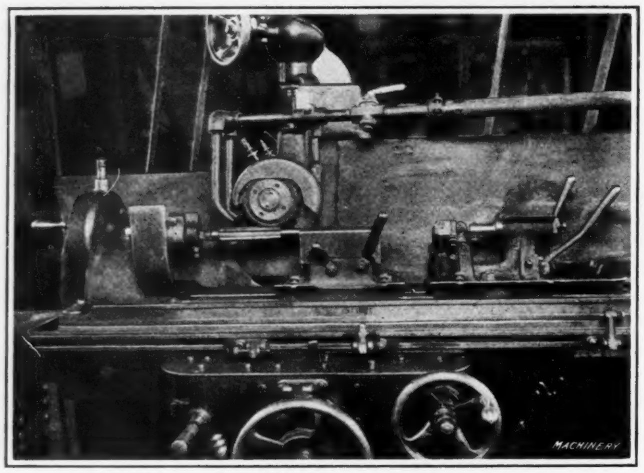


Fig. 59. Set-up on a No. 20 Bath Multiple-key Shaft Grinding Machine for grinding a Splined Transmission Shaft

tage is taken of the wide face wheel, trued to different tapers, and bringing it straight in on the work. This, combined with traversing the work, enables the greatest production to be obtained on this peculiar shape of rifle barrel.

For information on the grinding of shrapnel shells by the form wheel method, reference should be made to the article "Shrapnel and Shrapnel Manufacture," in the April, 1915, number of MACHINERY.

Form Grinding Splined Shafts

Splined shafts for automobile transmissions present another application of the form wheel to straight and circular surfaces. For this class of work, as a rule, a No. 20 Bath multiple-key shaft grinding machine is used, as shown in Fig. 59. This machine carries a form wheel which simultaneously works on both sides of the spline, and also on the radius between the splines. The wheel is kept trued up to the proper shape by means of the special wheel truing device, shown to the right of the illustration, which will be described in a subsequent article. The work, as shown, is held on centers and is driven by a dog in the usual manner. The head carrying the headstock center is rotated to index the work around for grinding the various splines, and several different methods are used for accomplishing this work. On the main drive shaft, shown at *A* in Fig. 60, the method of grinding is to first rough-grind all around the shaft to within 0.002 inch of the finished size, then true up the wheel with a special wheel-truing device, and take a finishing cut all around, four to five traverses per each spline being made for roughing and two traverses for finishing. On the example shown at *B* in Fig. 60, which is practically the same type of shaft, the method of handling is the same, but a different wheel is used. For example *A*, a Detroit combination wheel, grain 10-14, grade F, is used. This wheel is a combination of two different size grains and two different bonds; the sides of the wheel which operate on the splines are of fine grain, hard bond, whereas the center is of coarse grain and soft bond. For the example shown at *B*, the wheel used is a Norton alundum, grain 46, grade M, of practically a straight grain throughout, and is not of harder bond on the sides than in the center. With the wheel used on example *A*, it is necessary to true it up before taking the finishing cuts on every piece, whereas the wheel used on example *B* turns out from twelve to fifteen pieces to each truing of the wheel. The production on example *A* is sixty pieces in ten hours, whereas the production at *B* is 100 pieces in nine hours. From a study of these two examples of work, it would appear that a hard side, soft center wheel is not as satisfactory from a production standpoint as a wheel of an even bond and grain throughout.

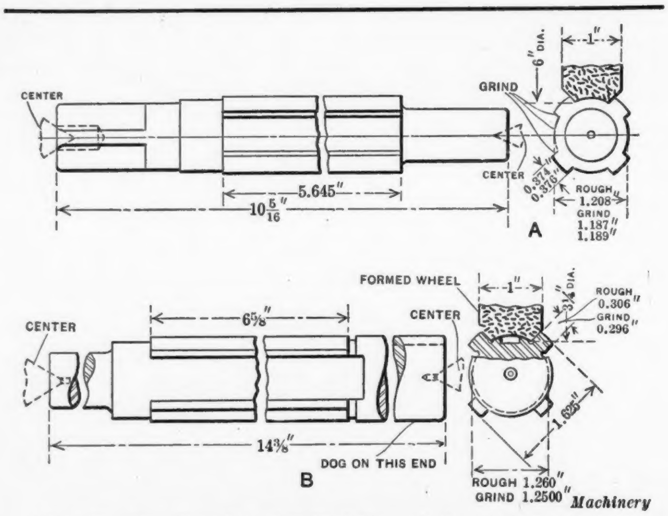


Fig. 60. Two Examples of Splined Transmission Shaft Work that call for the Use of Formed Grinding Wheels

A

Work:—Main transmission drive shaft, 0.20 per cent carbon, open-hearth steel, carbonized and hardened.

Operation:—Form grinding splines and radius with a Detroit (vitrified) combination wheel, grain 10-14, grade F; 6 inches diameter, 1 inch face; speed, 3185 R. P. M.—5000 feet surface speed; traverse work speed, 4.3 linear feet per minute: amount removed, 0.010 inch from each side of splines; 0.020 inch from diameter.

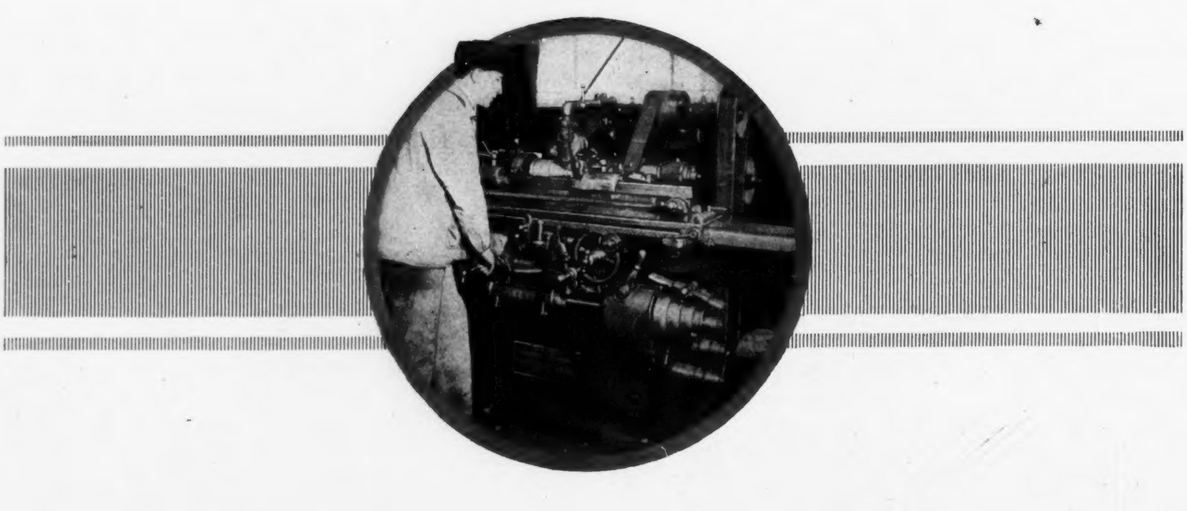
Remarks:—Sides of splines and radius are first rough-ground all around to within 0.002 inch of finished size, then wheel is trued with a special wheel truing device and shaft is finish-ground all around; number of traverses, four to five for each spline for roughing, two traverses for finishing. A combination wheel with hard bonded fine grain sides, and soft bonded coarse grain center is used; production, 60 pieces in ten hours; machine used, No. 20 Bath multiple-key shaft grinding machine.

B

Work:—Main transmission drive shaft, 0.50 per cent carbon steel drop-forging, hardened.

Operation:—Form grinding splines and radius with a Norton (vitrified) alundum wheel, grain 46, grade M; 3¼ inches diameter, 1 inch face; 2500 R. P. M.—2125 feet surface speed; traverse work speed, 8¼ linear feet per minute; amount removed 0.007 to 0.010 inch from each side of the splines; 0.014 to 0.020 inch from diameter.

Remarks:—Sides of splines and radius are first rough-ground by indexing the work after each traverse of the wheel, and two or three complete indexings made for roughing and finishing; wheel trued with special truing device; 12 to 15 pieces turned out per truing of wheel; production, 100 pieces in nine hours; 300 pieces ground by one wheel; machine used, No. 20 Bath multiple-key shaft grinding machine.



GRINDING CROWNED PULLEYS*

FORMING THE CROWN WITH WIDE FACE WHEELS

BY HOWARD W. DUNBAR†

Howard W. Dunbar‡

ONE of the very simple and effective discoveries in the application of belting to the transmission of power has been the crowning of the face of the pulley, *i. e.*, making the center larger in diameter than the edges, for the purpose of guiding the belt in a straight line and thereby keeping it in position without using such mechanical means as belt guides or flanges for this purpose. This has been an important discovery, but like many other simple mechanical laws applied in machines, the publication of information regarding the proportioning of the crown on a pulley has been so sadly neglected that almost every individual has his own views and ideas as to just how much or how little a pulley should be crowned to accomplish the desired results. We find in the numerous handbooks represented to be authorities on all subjects they treat almost as many different formulas and rules for determining the crown for pulleys as there are authors or handbooks. Some even go so far as to say that "the figures must be modified to meet the individual conditions." Of course, theoretically, low speeds require a higher crown than high speeds; leather belting higher crowns than cotton belting; wide pulleys and belts higher crowns than narrow ones, etc.

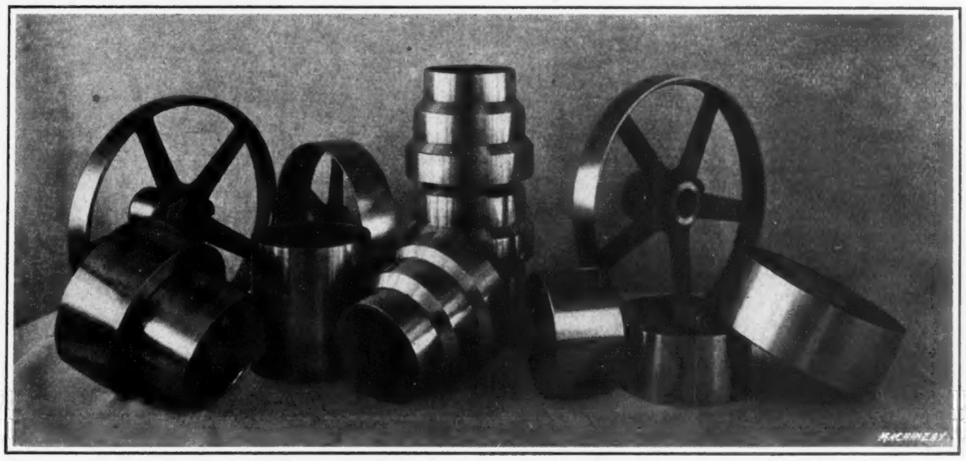


Fig. 1. Examples of Pulleys on which Crowning Operation was performed on Norton Grinding Machine. Note Special Cone Pulleys in Center of Illustration, on which Angular Faces between Steps were finished by Grinding

Some authorities recommend that the height of the crown should be 1/20 of the width of the face of the pulley, some 1/24, some 1/8 to 1/4 inch in height per foot of width, and so on indefinitely. The crowning or increasing of the diameter of the pulley at the center makes it possible to dispense with flanges or mechanical means for guiding the belt, due to the tendency on the part of the belt always to climb to the high point on the pulley. Consequently, the crown has but one object, and that is to guide the belt. The ideal condition for the transmission of power, insuring the greatest efficiency of the belt, is when the face of the pulley is absolutely straight and true. Therefore the nearer we can approach this condition, the more efficient will be the belt.

There are two principal factors which determine the position that a belt takes upon a crowned pulley, and these are modified by each other. First: The exact location of the highest point of the crown on the face of the pulley. Second: The diameter of the two extreme edges of the pulley. To insure the belt driving in its proper place on the pulley, the highest point of the crown should be exactly in the center, and the two edges of the pulley of exactly the same diameter, so that the nearer these conditions can be approached, the more ideal will be the drive.

The common method of crowning pulleys in general use is by two tapers, as illustrated in the left-hand view of Fig. 4. This method is selected principally because of its easy application in manufacturing (excluding the grinding process as a means of producing crowns) and has always been looked upon as being inefficient. The curved face crown, when the curve can be held uniform throughout, is a better means of crowning and more effective. The illustration of the position of the belt in Fig. 4 has been exaggerated to show the effect of crowning the pulley by the two-taper process. It will be noticed that the greatest tension on the belt is at point *C*, and naturally a strain is imposed at this point. The really effective driving is done somewhere between the center and outside edges, and may be represented by the space between *A* and *B*. Because of the stiffness of the belt (which is increased as the speed increases) the belt has a tendency to assume the position shown by the illustration. Although in actual practice the belt has the appearance of touching the pulley face all over, the pressure between the two extreme edges varies at different points, being the least near the edges and the greatest at the center. The real effective driving portion of the belt is between the points *A* and *B*.

The crown shown in Fig. 4 is accurate in height and in accordance with an approved formula taken from one of our prominent reference books. On the right of the same illustration is shown a pulley crowned by the grinding process, employing a straight-in cut. It will be seen that this crown has a symmetrical curve throughout the entire face of the

Fig. 2. Truing Device for producing Required Concavity in Wheel for grinding a Specified Height of Crown on Pulley

* For additional information on the crowning of pulleys published in MACHINERY see also "Crown Faced Pulleys," by George N. Vanderhoef, April, 1913, and "Pulley Crowning," by George A. Gauthier, September, 1905.

† Assistant Mechanical Engineer, Norton Grinding Co., Worcester, Mass.

‡ Howard W. Dunbar was born in Stockbridge, Mass., in 1882. He served an apprenticeship with the Stanley Instrument Co., Great Barrington, Mass. He has worked for the New York Adding Typewriter Co., Pike Adding Machine Co., J. N. Quinby & Co., Ellis Adding Typewriter Co., Western Electric Co., and Norton Grinding Co., holding the positions of draftsman, model maker, designing engineer, methods engineer, chief tool designer and assistant master mechanic. His specialties are manufacturing methods, the manufacture of small interchangeable parts, tools and grinding. He is now assistant mechanical engineer with the Norton Grinding Co., Worcester, Mass.

pulley. By this practice it is possible to produce pulleys with a crown of the minimum height, and because of the accuracy of the crown it will still guide the belt. The two extreme diameters on the edges of the pulley are held to a given dimension within a limit of 0.001 inch, the curve being symmetrical from edge to edge, which insures the highest point of the crown coming at the center and gradually decreasing toward the edges, with no abrupt differences in diameter from point to point. The fact that the belt lies uniformly over the face of the crown and approaches the ideal condition of a flat surface on the pulley, insures driving qualities and a power transmitting ability in the belt which are materially greater than when a crown is employed using the two-taper method produced by the old practice.

Extensive investigations on the shape and height of the crown for pulleys lead to the statement that for ordinary conditions employed in the operation of machine tools, and with the ordinary materials generally used for such purposes, the speeds, belts (whether leather or cotton), etc., have little bearing on the required height of crown to insure a satisfactory guiding of the belt, if such a crown is produced by grinding. The width of the face of the pulley is really the only important factor. This follows because of the possibility of producing the pulley face with a curve which is symmetrical throughout from edge to edge, and with diameters at the extreme edges of the pulley so nearly alike that the effect of their difference is negligible. A formula used by the Norton Grinding Co. which in actual practice is producing satisfactory work is: 1/200 of pulley face plus 0.02 inch = height of crown.

Pulleys crowned to this formula are illustrated by Fig. 1. By the wide face grinding process it is also possible to produce, in addition to the crowning of the face, other shapes in connection with the pulley diameter. This feature is illustrated by the special pulleys shown in the center of Fig. 1. Here the angular face which reaches from one cone step to the other was formed at the same time that the crown was put on the various steps of the cone. This is convenient in crowning the faces of tight and loose pulleys where the loose pulley is of a lesser diameter than the tight. A special fixture is necessary in doing such work, but is not treated in this article. The fixture for truing the wheel to grind crowns is shown in Fig. 2. This attachment is tilted on an angle with relation to the axis of the wheel to be trued. The degree to which the body of the fixture is tilted determines the amount of concavity in the wheel, which, in turn, determines the height of the crown on the pulley. The slide carrying the diamond is moved back and forth across the wheel in a straight line by the handwheel connected with a rack and pinion for this purpose. At the swiveling point, graduations are supplied which provide an easy means for setting the fixture, and a central graduation on the slide indicates the position of the diamond when in the center of the wheel.

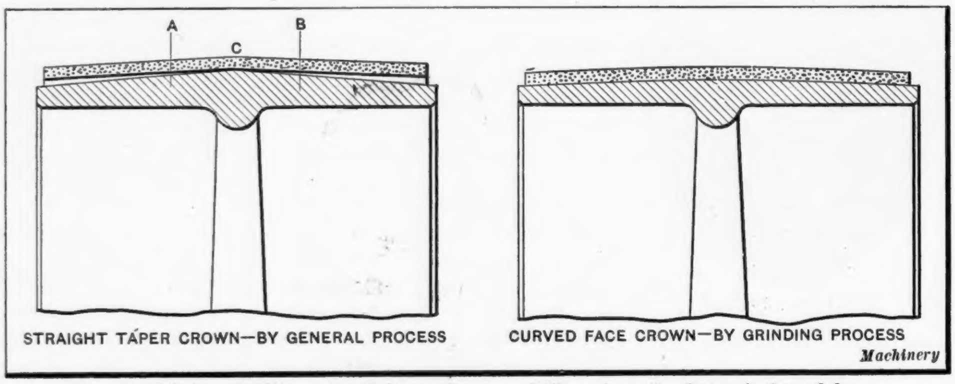


Fig. 4. Relative Conditions of a Belt running on a Pulley where the Crown is formed by a Double Taper and One where the Crown is formed by a Uniform Curve

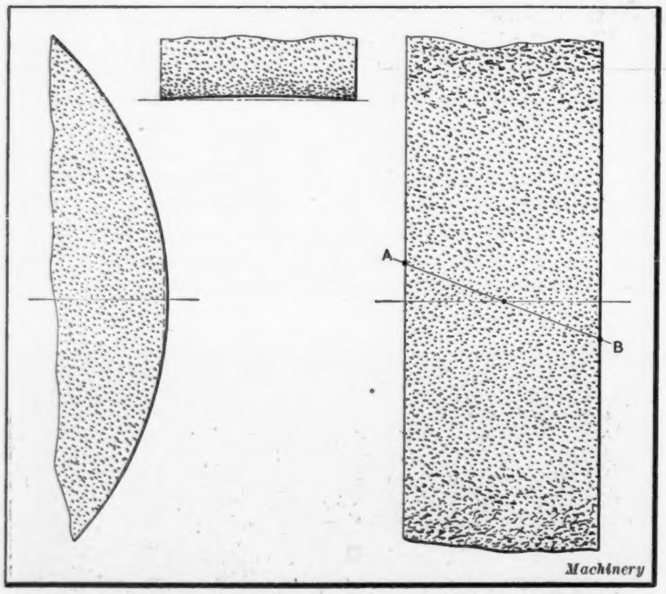


Fig. 3. Diagram illustrating Principle on which Concave Wheel Truing Device operates

Reference to the diagram Fig. 3 will show how the diamond causes the face of the wheel to be properly trued to produce a crown on the pulley. The fact that the diamond carriage is tilted at an angle, and that the diamond travels across the face of the wheel on a diagonal, causes the diamond to cut deepest as it passes across the center of the wheel and is midway between its two edges. The left-hand projection in the diagram illustrates this feature. Because the wheel is receding above and below the center line, as the diamond rises or falls on either side of the center line, it is cutting away less of the wheel, so that at points *A* and *B* it runs out into nothing, while it is removing the most material in the center. Different degrees of depth of cut can be accomplished by changing the angle of the path that the diamond travels on, so that it will be seen that if it travels on a path parallel with the axis of the wheel, the depth of cut will be the same at all points. The capacity of this attachment provides for truing on a straight line, and from this up to a concavity in the wheel having a depth of ¼ inch. In width, the attachment will true wheels up to 12 inches, which at the present time is the widest wheel used on a Norton grinding machine.

It must be borne in mind in crowning pulley faces in this manner, that the wheel is traveling straight into the work and does not travel laterally, so that the form in the wheel is what actually produces the crown on the pulley. This is only one other phase of the application of the wide face wheel and straight-in cuts for form grinding work. The production of work by this process is in proportion to the degree of accuracy required for the finished product, and varies with each individual case, depending upon the amount of material to be removed, the kind of material being ground, the width of the face of the pulley, the diameter of the pulley, and the many other variables that must be taken into consideration in all grinding problems.

* * *

The contributor of an article on wire-forming machinery recently published in MACHINERY has received many letters from all parts of the country, representing widely diversified industries. The writers of the letters had need of machinery of the sort described, although in some cases they were connected with establishments which to the casual observer would seem to have no use for metal-working machinery whatsoever. A large meat packing house, for instance, needed automatic wire-forming machinery to make can-openers, skewers and other wire products used in the preparation of food. So it is with many other large concerns. The more efficiently they are operated, the more likely they are to be buyers of machinery and of machine tools for its repair.

THE ADJUSTABLE WEDGE STOP IN JIG AND FIXTURE DESIGN*

A REVIEW OF THE DEVELOPMENT OF A SATISFACTORY FIXTURE DETAIL

BY R. E. McCOY†

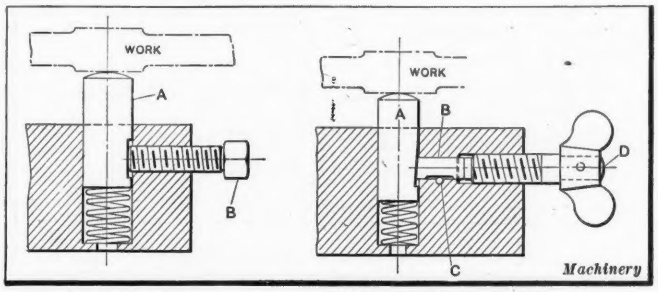


Fig. 1. Simple Type of Adjustable Stop

Fig. 2. Improvement on Stop shown in Fig. 1

IN the design of jigs and fixtures for light castings, it is always necessary to support the work directly under the cut when accuracy is desired. If the work is not supported directly under the cut, it will spring away from the cutter at that point. If it springs only a thousandth of an inch or two, it will cause trouble where the limits are close, especially if the work is to be interchangeable.

In machining castings the best results are obtained by locating from the web of the casting, allowing the casting to rest on three points; if more than three points are used, the casting will rock, owing to its uneveness. It is also necessary that the bosses to be machined be supported by individual supports. These supports must be made adjustable; they must also be very sensitive, so that no strain will be put on the casting when locating it in the fixture. Profiling and milling fixtures are the best examples of cases where adjustable stops must be used. There are many designs, but a great majority of these are failures, because they do not accomplish the purpose for which they were designed—

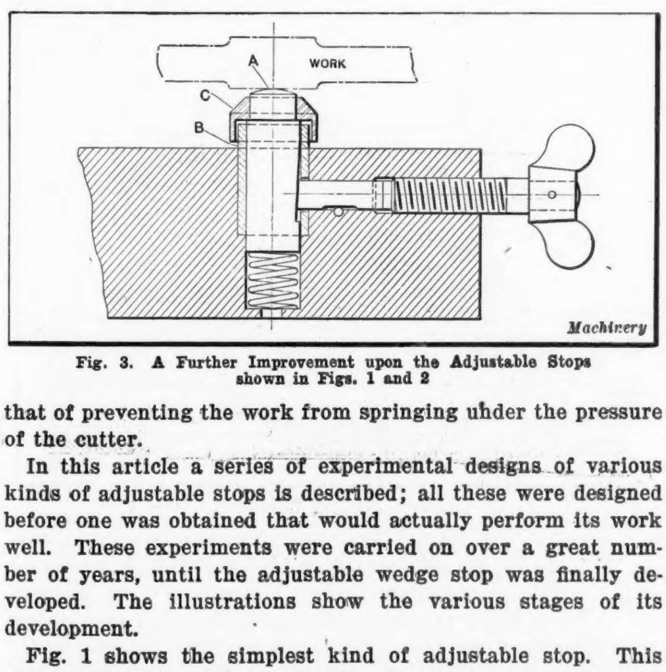


Fig. 3. A Further Improvement upon the Adjustable Stops shown in Figs. 1 and 2

that of preventing the work from springing under the pressure of the cutter.

In this article a series of experimental designs of various kinds of adjustable stops is described; all these were designed before one was obtained that would actually perform its work well. These experiments were carried on over a great number of years, until the adjustable wedge stop was finally developed. The illustrations show the various stages of its development.

Fig. 1 shows the simplest kind of adjustable stop. This stop is unsatisfactory, because the plunger *A* slips back under the pressure of the cutter, and the stop clogs up with dirt so that it will not work. Considerable time is lost in sending the fixtures to the tool-room to be overhauled, made necessary by their clogging up and sticking. The method of clamping the plunger is very slow, as it is necessary for the operator to use a wrench in tightening and loosening the set-screw *B*.

Fig. 2 is an improvement over Fig. 1. The plunger *A* has a slight angle milled on the side instead of the straight cut in Fig. 1, to keep it from slipping back. A piece of hardened drill rod *B*, kept from turning by a small pin *C*, is added for the screw *D* to clamp against. A wing nut is fastened to the screw to do away with the necessity of using a wrench. This stop is not satisfactory, however, because it shifts in tightening; the angle milled on the side of the plunger keeps it from slipping back under the pressure of the cutter, but it does not keep it from slipping back while it is being tightened. The stop also clogs up with dirt the same as the stop shown in Fig. 1.

Fig. 3 is an improvement over Fig. 2. A bronze bushing *B* is driven into the base of the fixture and allowed to project above the base as shown. The plunger *A* has a sliding fit in the bushing. A dirt shield *C* is driven onto the end of the plunger and extends down over the outside of the bushing as shown, making the stop fairly dirt-proof; but this

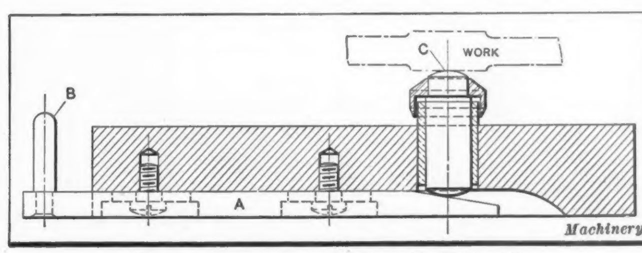


Fig. 4. Simple Form of Adjustable Wedge Stop

stop is not satisfactory because it shifts in tightening, the same as the stop shown in Fig. 2.

Fig. 4 shows the next step taken to overcome the troubles already described. The thumb-screw and spring plunger shown in Figs. 1, 2 and 3 has been abandoned and a sliding wedge *A* added in its place. The wedge is provided with a handle *B*, attached so that it can be operated easily, and is held in place by two shoulder screws that are inserted through two elongated slots milled in the wedge. It was thought that at last a stop had been designed that would perform the work for which it was intended, but when put into actual use on a fixture it proved to be a failure, because the wedge would slip back owing to the vibration of the machine while in operation; this permitted the plunger *C* to drop down.

The next improvement in the stop is shown by the addition of an "anti-slipper" to prevent the wedge from slipping back, as shown in Fig. 5. The handle *B* in Fig. 4 has been abandoned and a stud has been riveted into the wedge *A* instead, the stud extending up through an elongated slot cut in the base of the fixture and threaded for the knurled nut *B*. When nut *B*, which also acts as a handle for shifting the wedge, is tightened, it clamps wedge *A* and anti-slipper *C*

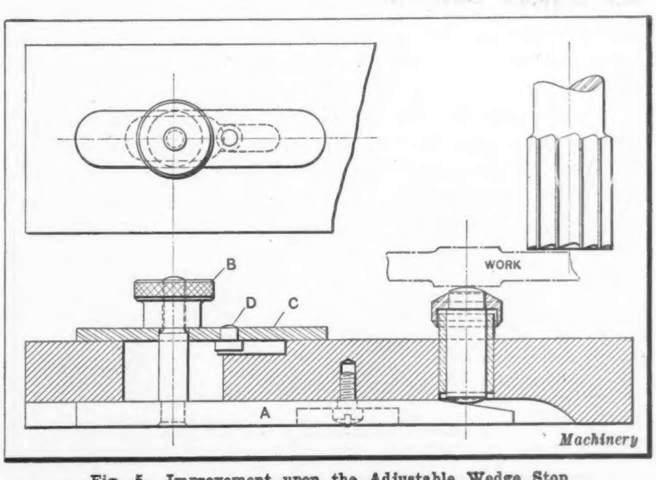


Fig. 5. Improvement upon the Adjustable Wedge Stop shown in Fig. 4

* For previous articles on clamping and locating devices used in jigs and fixtures see "Jig and Fixture Design," March, 1915; "Clamping Work in Jigs," December, 1913; and "Jigs and Fixtures," April, May, June and July, 1908. See also MACHINERY's Reference Book No. 41, "Jigs and Fixtures."

† Address: 566 W. Third St., Dayton, Ohio.

against the base; this prevents the wedge from slipping back as a result of the vibration of the machines on which the fixtures are used. The anti-slipper also acts as a covering for the slot cut in the base, thus acting as a dirt shield, and is kept from turning when tightening and loosening the nut by a stud *D* driven into it and sliding in a slot cut in the base as shown. This wedge, however, failed when in actual use, because it would spring down under the pressure of the cutter, due to slight unevenness of the platens of the machines where the fixtures were used.

Hence it was improved upon by the design shown in Fig. 6; the flat style of wedge shown in Figs. 4 and 5 was abandoned for a wedge *A* made of drill rod, sliding in a hole drilled in the base of the fixture; the stud *B* was screwed into the back end of the wedge instead of being riveted, as shown in Fig. 5, so that it could be easily assembled. The bushing *C* was provided with a shoulder, and a headless set-screw *D* was added to prevent the plunger *E* from dropping out and getting lost, as it did sometimes when the fixtures were not in use. This design, however, was not sensitive, due to too much friction on the wedge *A*, and to dirt that would work under the anti-slipper *F*; therefore it was impossible for the operator to feel when the stop had a bearing against the work.

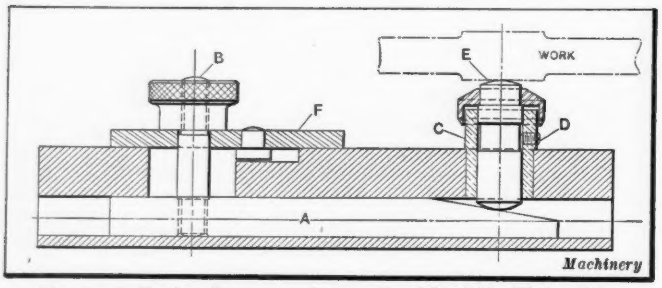


Fig. 6. A Further Improvement upon the Adjustable Wedge Stops shown in Figs. 4 and 5

Fig. 7 is practically the same design as Fig. 6; the only change made is in the bushing *A*, which has been lengthened so that it will act as a support for the end of wedge *B*. Bushing *A* is made of cold-rolled steel, carbonized and hardened, instead of bronze as before, in order to obtain more strength and better wearing qualities. The base is also cut away as shown; this method of construction removes about one-half the friction that caused the failure of the stop shown in Fig. 6; but this stop was still not as sensitive as it should be to get ideal working conditions.

Fig. 8 illustrates the next step taken to improve the stop; this design practically overcame all the objectionable features already mentioned. The bushing *A* has been lengthened and given a much larger shoulder to insure still better lining conditions. A small pin *B* replaces the headless set-screw in Figs. 6 and 7, which keeps the plunger from falling out and getting lost. The arrangement for clamping the wedge has been changed considerably. The bronze casting *C* is the added feature. A hole has been cut in the base into which the casting has been inserted, permitting it to have clearance all around. This allows it to be easily lined up with the plunger. The casting is held in place by two fillister-head screws and dowels. Two holes have been drilled in the casting; these holes act as a support for the back end of the wedge, as shown, the front end being supported in such a manner that it has the minimum amount of friction, making it very sensitive. The casting *C* also supports and at the same time raises the anti-slipper *D* from the base of the

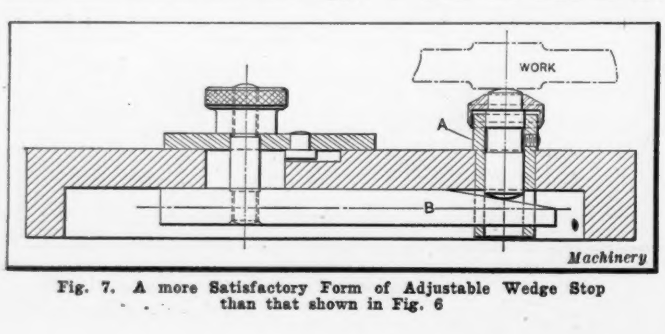


Fig. 7. A more Satisfactory Form of Adjustable Wedge Stop than that shown in Fig. 6

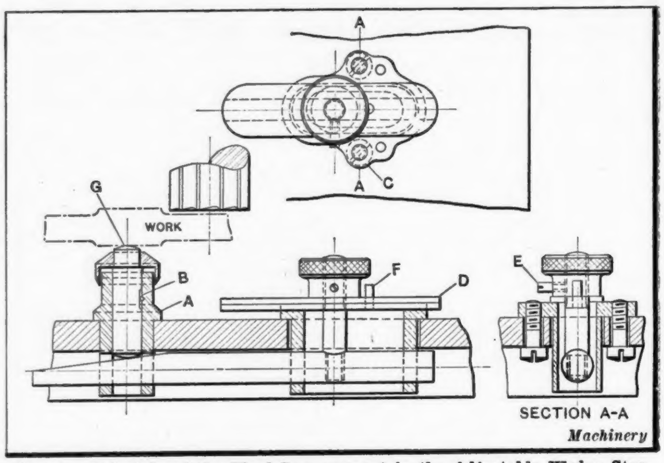


Fig. 8. Principle of the Final Improvement in the Adjustable Wedge Stop

fixture, making it dirt-proof also. In Figs. 5, 6 and 7 a stud driven into the anti-slipper and sliding in a slot cut in the base of the fixture, prevents it from turning when the knurled nut is tightened or loosened, but in Fig. 8 a tongue cut on the anti-slipper and having a sliding fit in a slot cut in the casting *C* answers the same purpose.

A stud *E* is screwed into the side of the knurled nut and a small pin *F* is driven into the anti-slipper; this pin acts as a stop for the stud, and prevents the operator from turning the nut more than is necessary in tightening and loosening.

We now have a stop that will not slip back under the pressure of the cutter and that does not shift in tightening; it is dirt-proof, thus saving time and the expense formerly caused by the presence of dirt; and the plunger is prevented from getting lost. It does not slip back due to vibration of the machines or spring down under the pressure of the cutter, due to the unevenness of the platens of the machines on which the fixtures are used. The device is simple and can be quickly operated, and it is so sensitive that the oper-

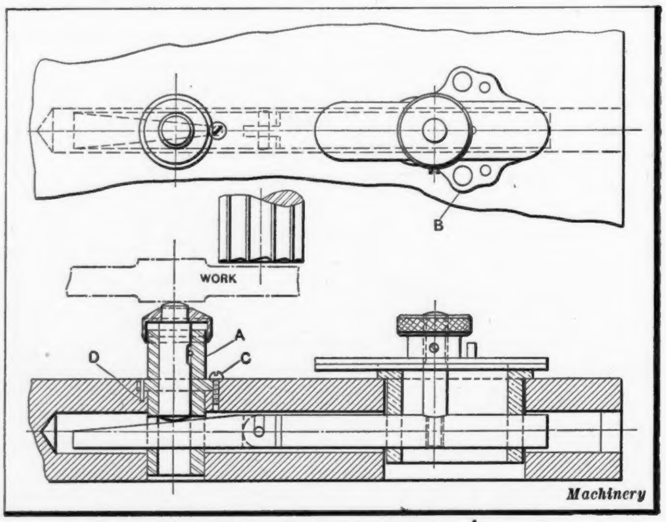


Fig. 9. The Adopted Form of Adjustable Wedge Stop

ator can feel the instant that the plunger *G* comes in contact with the work. It was found, however, that owing to so many large holes being drilled in the base of the fixture, and so much being cut away from underneath when locating the adjustable stops on the base, that the base became weakened and that it would spring out of shape. This was overcome by drilling a clearance hole for the wedge. The end of the hole was provided with a wooden plug to keep out the dirt as shown in Fig. 9; the toolmakers also complained of the great difficulty encountered in lining up the holes in bushing *A* with the holes in casting *B*. This was remedied by making the bushing an easy fit; the small pin *D* and round-head screw *C* were added to keep the bushing from turning or working loose.

The wedge itself was jointed and made in two parts to take care of the variations vertically that might occur in drilling the holes in the bushing and casting in which the wedge slides. This practically made the wedge self-aligning,

and reduced the friction on the wedge caused by the holes not lining up properly with each other.

We have here an adjustable stop that is desirable in every way. It performs its work exceedingly well. It is easily assembled on the fixtures under all conditions, and because of the stops being made in large quantities and carried in stock in the tool-room, it is inexpensive to make.

Application to the Design of a Fixture

Fig. 10 shows the construction drawing of a simple profiling fixture. It will give a good idea of just how the adjustable wedge stops are used. The casting *A* to be machined is shown by the dot-and-dash lines, located in the fixture and resting on three studs *B*. The bosses to be finished are marked *f*. As this is the first machining operation, the necessity of having adjustable stops under the bosses to be finished, in order to get an accurate product from the fixture, is obvious.

The Pneumatic Adjustable Wedge Stop

We will now proceed to the pneumatic adjustable wedge stop. This type represents the highest development of adjustable stop, but owing to the fact that an equalizing valve and an operating valve have to be used in conjunction with the pneumatic stops, no matter if there is only one or if there are a dozen stops needed on the fixture, and owing to the high class of workmanship necessary to make the stops as well as the valves work successfully, it is not advisable to use the pneumatic adjustable type on fixtures needing only a few stops. It is not economical, for instance, in the fixture shown in Fig. 10, because the time saved in operating the pneumatic adjustable stop is too small in this case; but when a large number of stops are needed, the time saved in placing the work in the fixture and its removal from the fixture after machining by the use of the pneumatic adjustable stops offsets by far the extra expense in making the stops. The cost of the finished product for one hundred pieces was in some cases reduced one-half and even two-thirds after this style stop was used, as it is only necessary for the operator to touch a valve, and all the stops are operated instantly.

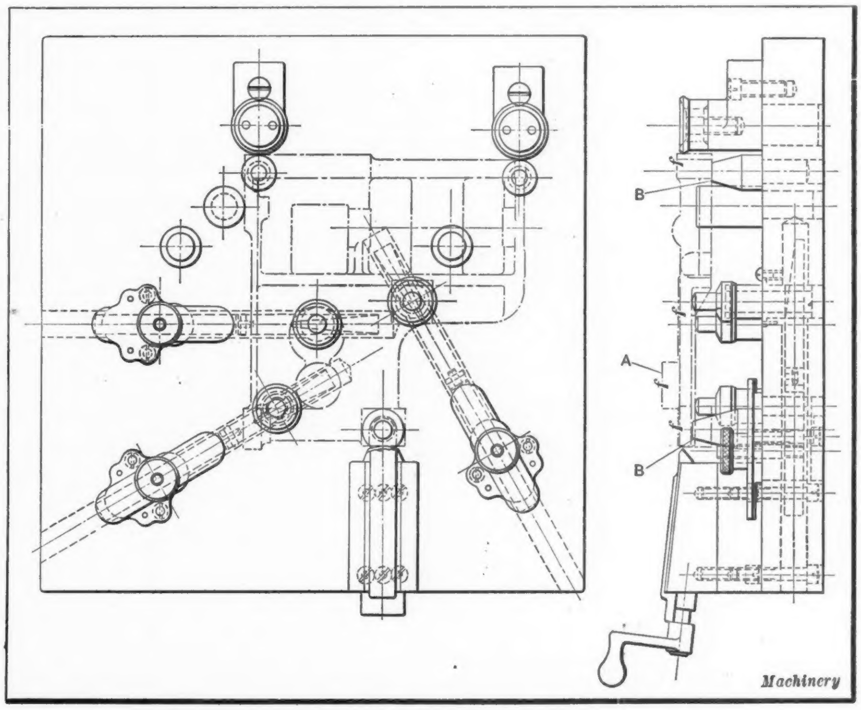


Fig. 10. Fixture in which Adjustable Wedge Stops are used

Fig. 11 shows a pneumatic profiling fixture on which the pneumatic adjustable wedge stops are used. The air from the main line enters the operating valve *A* located in the lower right-hand corner of the fixture, by passing through a hole drilled in the base and then up through a small brass tube which enters the side of the valve, as shown; from there it is distributed through small tubing around to the various stops throughout the fixture, the arrows shown indicating the flow of the air.

Sections *A-A* and *B-B* show the position of the ports cut in the valve stem *B* after the work is located in the fixture ready to be machined. As the conditions under which the operating valves are used vary, the position of the ports and air holes in the stem *B* and the air holes and the slots through which the brass tubing passes that distributes the air to the various stops, must suit these conditions, but the general design of the valve always remains the same. Rubber packing is placed around the tubes where they pass through the base of the valve to prevent any leakage of air at that point.

The body of the operating valve *A* is made of a bronze casting and is held in position on the base of the fixture by two screws. The valve stem *B* is made of hardened tool steel and ground to insure a perfect air-tight working fit. The handle *C* is held on the stem by the flat-head screw *D*. The small pins *E* act as stops and insure that the valve stem *B* is always located properly when the valve is operated. By means of the oiler shown on the side of the valve, oil can always be distributed around to the various stops. This keeps them properly oiled and in good working condition at all times. The equalizing valve *F* can be placed in the most convenient position, and its position on the line of tubing is generally governed by the design of the fixture. It exercises the same control over the pneumatic stops wherever it is placed on the line of tubing. It is very important that the equalizing valve be always kept in good working order and properly adjusted to suit the existing conditions, as it must have absolute control of the distribution, to maintain and equalize the amount of air pressure on each stop at all times, and lock all the stops in position after the functions just described have been performed.

The detailed construction of the equalizing valve is as follows: Body *G* is a brass casting having two slots cut in the base through which the brass tubes that distribute the air pass, and around which rubber packing is placed to prevent leakage at the point where the air enters the valve. The mechanism of the valve is of very simple construction, as will be seen from the illustration, and is composed of a medium hard rubber ball *H*, a spring *I* made of brass wire, a cap *J* made of sheet brass, which prevents the spring *I* from injuring the rubber ball *H*, an adjusting screw *K* made of cold-rolled steel and casehardened, and an adjusting nut *L* made of brass and kept from turning on the screw *K* by small grooves cut in the body *G*, whereby the proper tension can be obtained on the spring *I*. Plug *M* screwed into the body *G* and the collar *N* that is held in position on the adjusting screw *K* by the headless set-screw *O* are also made of brass. As much brass is used in the construction of the valve as possible, because the moisture in the air used to operate the stops does not corrode the working parts when made of brass. This, of course, is an important point in a fixture of this kind.

The body *P* of the adjustable stop *Q* is also made of brass. The tubing passes through two slots cut in the base of the body and around which rubber packing is placed to prevent the leakage of air at the point where it enters the stop. The piston *R* and the plunger *S* are made of tool steel, hardened and ground. The object of using the two headless set-screws *T* is to insure that the piston *R* is always kept in proper alignment and to prevent the plunger from dropping out. Cap *U* placed on the end of the plunger *S* makes the stop dirt-proof. The plugs *V* screwed into the body *P* are made of brass. The small ends turned on the plugs act as bumpers to control the maximum travel of the piston *R*.

After the piece to be machined has been located in the fixture and clamped in position, the handle *C* of the operating valve is turned from the position shown by the dotted line in the end view, as indicated by the arrow, until it comes in contact with the stop pin *E*. The port cut in the valve stem *B*, also shown in detail by the cross-section *B-B*, is then open for the free passage of the air through the valve. The air then enters the line of tubing which leads to the adjustable stops *Q* through a small hole drilled in the body of the valve and indicated by the arrows which show the direction of the flow of the air through the tubes. From the line of tubing *W* the air enters the stops through a small hole, forcing the piston *R* forward. As the plunger *S* rests on the taper that is cut on the piston, the plunger is forced upward until it comes in contact with the work.

The equalizing valve *F*, by the aid of the adjusting screw *K* and the adjusting nut *L* has been adjusted so that the instant the plunger *S* of the adjustable stops comes in contact port is opened as shown in the lower section of *B-B*, permitting the air in the line of tubing *W* that moved the plunger *R* of the adjustable stops forward to exhaust through a hole in the end of the valve stem *B*. As the air pressure on the rubber ball *H* of the equalizing valve is reduced, the spring forces the ball to move back to its seat in the valve; this closes the valve and prevents the air in the line of tubing *X* from leaking out through the exhaust hole by way of the line of tubing *W*. The port on section *A-A* of the valve stem is now open, permitting the air from the main line to pass into the line of tubing *X*, from which it enters the adjustable stops *Q* and forces the piston *R* back, thus permitting the plungers *S* to drop back to their original position.

The air pressure on pistons *R* is maintained until the handle of the operating valve is moved in the direction and over to the position indicated by the arrow. As the handle is turned, and an instant before the port in the valve stem that will permit the air from the main line to rush into the line

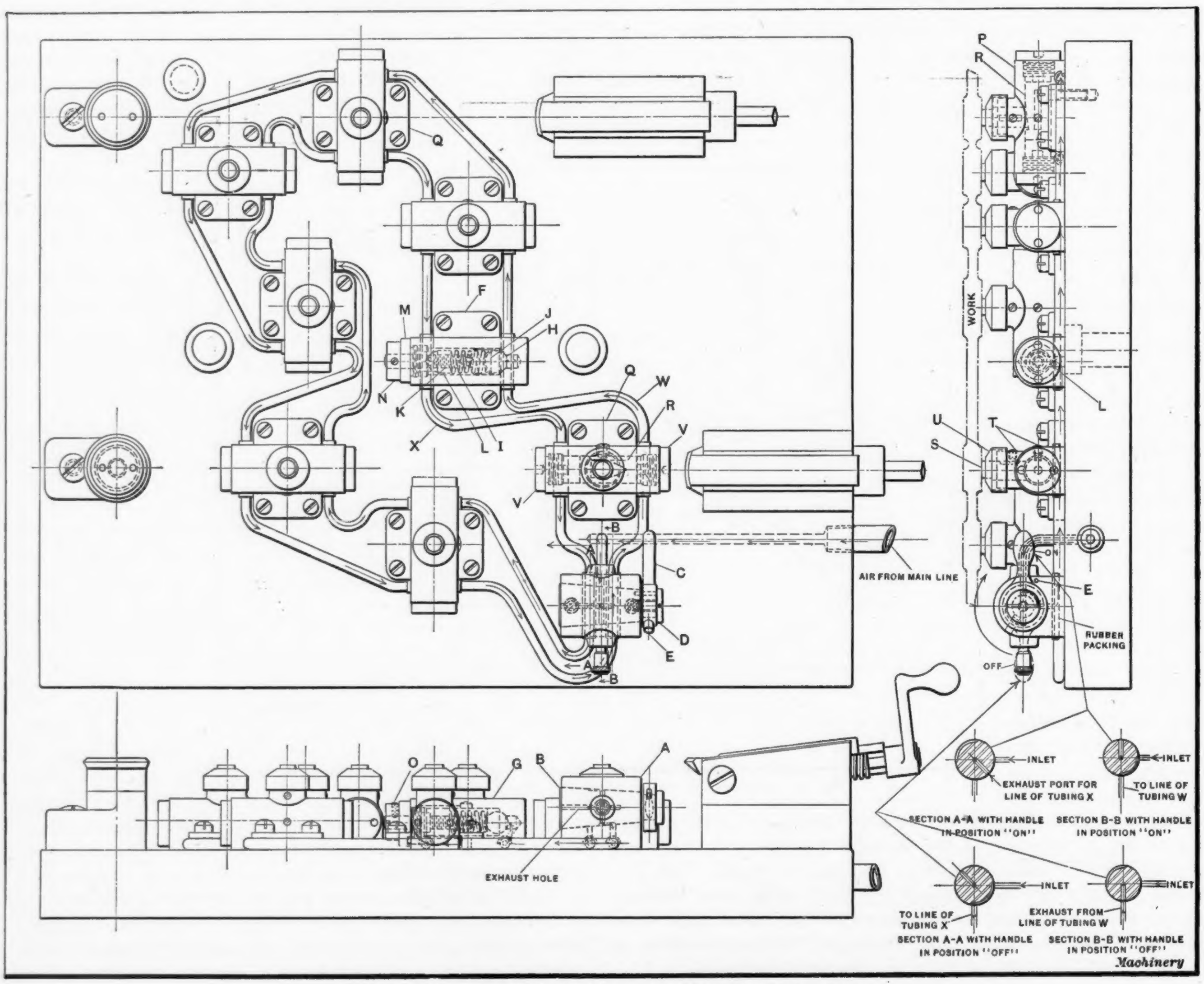


Fig. 11. Fixture provided with Pneumatic Adjustable Wedge Stops

with the work—not sufficiently to put any strain on the casting, but barely touching it—the air pressure causes the rubber ball *H* in the valve *F* to move back from its seat and let air through the valve into the other line of tubing *X*, as indicated by the arrows. The air passes through the tube and through a small hole into the stop whose plunger *S* has come in contact with the work, the air entering the space in the adjustable stop at the other end of the piston *R*. The air pressure thus becomes the same on both ends of the piston, after the plunger has obtained a bearing against the work.

When the work is ready to be removed from the fixture the handle *C* of the operating valve *A* is moved back to the position indicated by the dotted lines. The port on section *B-B* of the valve stem is now closed, shutting off the supply of air from the main line, and at the same time the exhaust of tubing *W* opens, all the air is permitted to be exhausted from the stops by way of the tube *X* through the exhaust hole in the end of the valve stem. This exhaust port is closed again before the port opens that lets air into the line of tubing *W*; this prevents the air that passes through the equalizing valve to the line of tubing *X* from leaking out through the exhaust hole in the operating valve *A*.

Clamping Features

A feature of the fixture shown in Fig. 10 is the simple and rapid method by which the work is clamped in the fixture. This design of clamp has great holding power and does not loosen owing to vibration; the clamp can be easily and quickly operated, and there is no danger of the cutter running into the clamps, as they do not project above the surfaces that are to be machined. It is only necessary to use one clamp on the fixture shown in Fig. 10, although in some

cases, as in Fig. 11, two or more are necessary. This single clamp not only keeps the work from tearing loose while machining, but it aids in locating the work in the fixture as well. This design of clamp is known as a knife-edge clamp, and is generally used in conjunction with stops known as knife-edge stops. These clamps and stops are made in large quantities and carried in stock, and are easily located on the fixtures as needed. Sometimes it is found necessary to elevate the clamps from the base of the fixture by means of spacing blocks. This has been done on both the fixtures shown in Figs. 10 and 11.

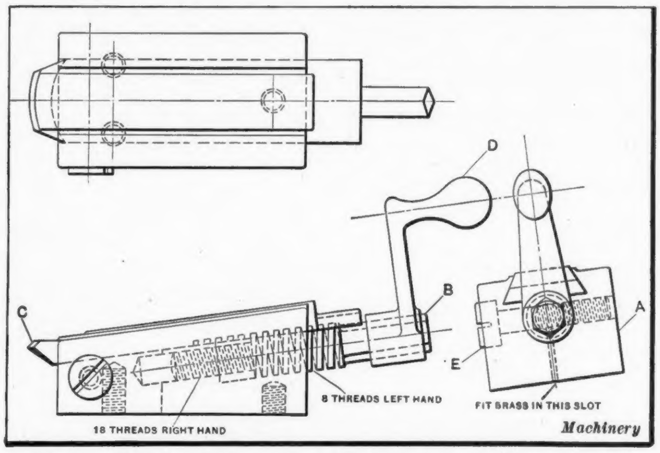


Fig. 12. Clamping Device used in Fixtures shown in Figs. 10 and 11

Fig. 12 illustrates the detailed construction of the clamp. The body *A* is made of cast iron, screw *B* is made of cold-rolled steel, carbonized and hardened, knife-edge *C* is made of tool steel, hardened, and handle *D* is a malleable-iron casting. To assemble the clamp, screw *B* is screwed into the tapped hole in body *A* as far as the threads will permit; then knife-edge *C* is slid up in the slot cut in the body until the square threads cut on the knife edge come in contact with the square threads on the screw. Now, by turning the screw with the aid of the handle, the knife edge is easily drawn up onto the screw to the working position. The front end of the body *A* has a slot cut in it into which a piece of sheet brass has been fitted as shown. This slot with the aid of the

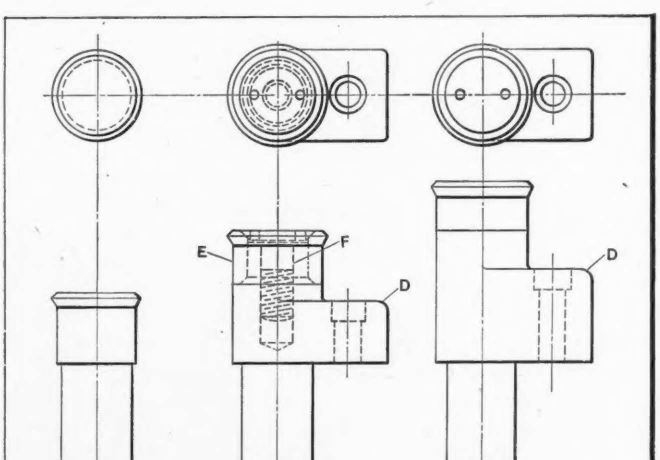


Fig. 13. Locking Points or Stops used in Fixtures shown in Figs. 10 and 11

clamping screw *E* takes up the wear and keeps the knife-edge always working snugly.

Fig. 13 shows the detailed construction of the three sizes of the knife-edge stop carried in stock. Stop *A* is made of tool steel, hardened and ground. As it is necessary to use stops of considerable height, for instance like those used on the fixtures shown in Figs. 10 and 11, a stop that will insure greater stability is necessary, so stops *B* and *C* were designed. The bodies *D* of these stops are of cast iron and can easily be adjusted to suit the height of the work by simply facing off the bottom of the body. The hardened and ground tool steel button *E* is held in place on the body by the screw *F* made of cold-rolled steel, carbonized and hardened. A specially designed spanner wrench is used in tightening the screw.

* * *

FIFTIETH ANNIVERSARY OF WORCESTER POLYTECHNIC INSTITUTE

The fiftieth anniversary of the founding of the Worcester Polytechnic Institute was celebrated at Worcester, June 6 to 10. The most important part of the celebration took place Wednesday, June 9. On that date representatives from over ninety universities and colleges, engineering institutions and societies all over the United States assembled in Worcester for the celebration exercises which were held in Mechanics Hall. At these exercises, the president of the Polytechnic Institute, Ira Nelson Hollis, presided, and among the speakers were the Hon. David I. Walsh, governor of Massachusetts, John A. Brashear, president of the American Society of Mechanical Engineers, and A. Lawrence Lowell, president of Harvard University. These exercises having taken place in the forenoon, a meeting was held in the afternoon in the lecture room of the Electrical Engineering Building, when George I. Alden, president of the Norton Co., a member of the Board of Trustees of the Polytechnic Institute, and formerly professor of mechanical engineering there, spoke on the ideals of the Washburn shops, which are connected with the institute for the training of mechanical engineers in shop practice. Prof. W. W. Bird, of the mechanical engineering department and director of the Washburn shops, also read an abstract of a paper to be presented at the Buffalo meeting of the American Society of Mechanical Engineers on "The Effects of Humidity on Leather Belting." At night a banquet was held at the Bancroft Hotel at which speeches were made by the Hon. John W. Weeks, senator from Massachusetts, Major General Leonard Wood, of the U. S. Army, Howard Elliott, president of the New York, New Haven & Hartford Railroad, and others.

The celebration, which was favored with excellent weather, marked a half-century milestone of an institution that has proved itself exceptionally practical in its ideals in engineering education, and from which have come a great number of leading engineers in all the fields of industrial endeavor. The institute was founded in 1865 as an institution of higher education by a gift of $100,000 from John Boynton, but it derived its peculiar character from the endowment of a commercial shop for the teaching of machine construction by Ichabod Washburn. This shop is operated in connection with the academic part of the institution as part of the instruction of students. At the time, the union of a commercial shop with an educational institution was considered an experiment in education, the idea being to associate an engineering college with what would correspond to a clinic or hospital connected with a medical school. The shop has consistently adapted itself to the times, and has always preserved a permanent organization of its own, entirely apart from the students. Workmen are employed the year round, and the students simply use the shops as a laboratory of work-shop management, and while they are engaged in the making of the tools and apparatus sold by the shops, the latter in no sense depend upon the students for their productive capacity. The students pass through a course of patternmaking with 124 hours, and then complete 376 working hours in the foundry, machine shop, and forge shop. In addition, they work during the summer a total of 432 hours in the various shops. The final work in shop training then takes the student into the office where he is placed in closer contact with actual business experience than he could be anywhere outside of a large commercial shop. A young man who has completed this work has a training which will advance him rapidly to usefulness in connection with management, it being strictly understood that the shops are not intended to train the young men to become expert mechanics, but merely to make it possible for them to gain an all-around knowledge of the problems met with in machine shop practice and industrial work generally, so that as engineers they will have a fair knowledge of all the branches of the machine-building industries.

Copyright, 1915, by THE INDUSTRIAL PRESS
Entered at the Post-Office in New York City as Second-Class Mail Matter

MACHINERY

DESIGN—CONSTRUCTION—OPERATION

PUBLISHED MONTHLY BY

THE INDUSTRIAL PRESS

140-148 LAFAYETTE STREET, NEW YORK CITY
51-52, CHANCERY LANE, LONDON, ENGLAND
Cable address, Machinery New York

Alexander Luchars, President and Treasurer
Matthew J. O'Neill, General Manager
Robert B. Luchars, Secretary
Fred E. Rogers, Editor
Erik Oberg, Franklin D. Jones, Douglas T. Hamilton,
Chester L. Lucas, Edward K. Hammond,
Associate Editors

Yearly subscription—$2.00; coated paper, $2.50; Foreign edition, $3.00. The receipt of a subscription is acknowledged by sending the current number. Checks and money orders should be made to THE INDUSTRIAL PRESS. Money enclosed in letters is at the risk of the sender. Changes of address must reach us by the 15th to take effect on the following month; give old address as well as new. Single copies can be obtained through any newsdealer.

We solicit contributions from practical men on subjects pertaining to machine shop practice and machine design. All contributed matter published exclusively in MACHINERY is paid for at our regular space rates unless other terms are agreed on.

JULY 1915

NET CIRCULATION FOR JUNE, 1915, 22,964 COPIES

GUARDING OUR NATIONAL REPUTATION

It is well known that a manufacturer may palm off an inferior product or disregard his business engagements in his own country, and only his individual reputation is affected; but when he commits these offenses in a foreign country the reputation of his nation suffers. This is particularly true of American manufacturers at present, and every American industry should guard with jealous care the reputation of its members; for every violation of commercial ethics by an American will be used with telling effect by our foreign competitors. For a trifling gain, one careless or unscrupulous manufacturer can inflict injury on the reputation of an entire industry that it will take years to repair. No business friendships nor questions of expediency should be considered in such circumstances, because it is a question of the common good. Every manufacturer should do his utmost to root out such offenses, be the offenders big or little.

* * *

GRINDING AND GRINDING MACHINES

Although grinding is one of the oldest processes used for shaping, polishing and sharpening tools, the history of machine grinding practically began in the sixties with the invention of the universal grinding machine by Joseph R. Brown of the Brown & Sharpe Mfg. Co. The original cylindrical grinder was a fourteen-inch Putnam lathe converted into a grinding machine by mounting a grinding wheel on the carriage. The grinding machine was regarded then and for many years after as purely a tool-room appliance to be used for the accurate finishing of hardened steel parts only. Since then the art of machine grinding has developed greatly, and now it is regarded by many as one of the most effective and rapid methods of machining cylindrical parts.

The limitation of grinding today is the grinding wheel, which although greatly improved as compared with the product of wheel makers forty or fifty years ago, is still imperfect. It consists of an aggregation of abrasive grains, either natural or artificial, united by various bonds, which present irregular cutting edges at all angles, many of them ineffective. The ideal grinding wheel is that in which all the cutting edges of the abrasive grains are properly shaped and presented to the work in the most effective position, like the teeth of a milling cutter. This ideal, of course, can hardly be attained by present methods.

The articles on grinding in this and following numbers are intended to bring together available material that will be useful to those concerned with the economical production of machine parts. Grinding is a difficult operation to analyze because of the many factors intimately associated in that work. It is more difficult than lathe work, as there are more points to be considered. The analysis made by Mr. Alden of the relation between work speed and depth of cut known as "grain depth of cut" is an important step toward the establishment of grinding on a rational basis. In these articles no attempt at analysis of this kind is made, but many examples of work are given describing the results obtained, and indicating what can be done mainly by showing what has been done.

* * *

INTEGRAL SHAFT SPLINES

The defects of inserted keys or splines in circular shafts of sliding-gear speed-changing transmissions had not been seriously studied by designers until the advent of the automobile. Early in the development of automobile change-gear construction these keys were found to be unsuitable. A shaft having a key laid in one side is considerably weakened by the keyway and the key soon loosens under the repeated shocks of use. When shifting a gear under load, twice the effort is required to move it along the shaft than when the gear is supported by two keys diametrically opposite; but two keys located opposite do not materially mitigate the trouble of loosening.

The weakness of the inserted key brought the square shaft into use for change-gear construction. Though this seemed like a reversion to an undesirable old-style form used years ago in mill work, because it was a commercial shape and required no turning the change, nevertheless, was a step in advance. A square shaft presents four solid angular "keys" to overcome torsional resistance, and the part sliding thereon can be moved more freely than when only one key is provided. The square shaft, however, is heavier than it need be for a given torsional strength, and as the requirements of automobile service became more severe, more key bearing surface than could be obtained with the square shaft of limited size was required. Designers then developed the integral spline shaft, that is a round shaft in which the keys or splines are produced by milling out the metal between, thus producing four, six or eight keys integral with the shaft. While it was an expensive process to mill the shafts and fit them to their gears it was well worth the cost.

When the advantages of the hobbing machine for gear cutting were recognized, some enterprising minds turned to the possibilities of hobbing splined shafts, with surprising results. Not only was it found possible to hob integral splined shafts, but it was found that it could be done at a rate so rapid that the cost of producing them was actually less than that of the square shaft.

The advantages of the sliding-gear shaft of the multiple spline type are so evident wherever construction demands sliding-gear changes, that machine tool builders are introducing it into the construction of milling machines and other machine tools. It has large area of spline surface, greater torsional strength than the inserted key shaft, and the cost is low. The broaching machine makes the problem of machining the hub for the reception of the multiple spline shaft a simple and rapid operation. It might be said that the broaching machine was the forerunner of the multiple spline shaft, inasmuch as it made the use of this improved form practicable. Without the broaching machine the cost of cutting multiple keyways as accurately as is demanded in modern practice would have been prohibitive. Thus the development of a machine tool opened possibilities of improvement in machine design practice generally. Not only has it effected improvement in machine practice, but the cost of production has been materially reduced. The cost of hobbing a multiple spline shaft and broaching a gear to fit it is lower than the cost of boring a gear, cutting a keyway, turning the shaft, cutting a keyway in it, and fitting a key—the usual practice before the development of integral splined shaft construction.

INDEXING TECHNICAL LITERATURE*

A SYSTEM THAT EDUCATES WHILE IT INDEXES

BY WALTER G. LOHMEYER†

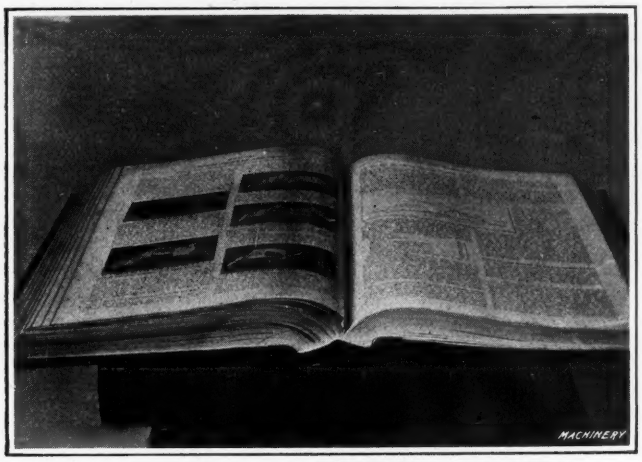


Fig. 1. Bound Volume of MACHINERY for 1912, used in connection with Card Index

THE subject of indexing has been given a great deal of space in technical papers, as each writer seems to lay stress on a particular feature applying to some specific use to which his index is put. No attempt will be made here to do more than roughly outline a system, but knowing the tendency of most men to go to extremes in this direction, the present article has been prepared with the hope that it may prove of value to those who have put off starting an index because they have found most systems too expensive and laborious. The main object of a good index is to enable one to find any desired information without the necessity of going over an innumerable number of books. The expense of the index in time and money must, of course, be commensurate with its practical value.

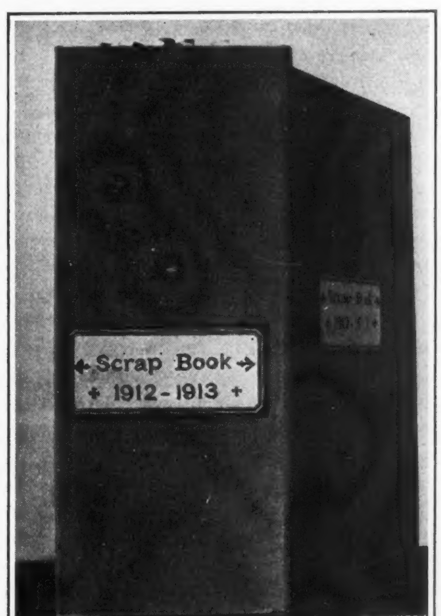


Fig. 2. Scrap Book in which Clipped Articles are preserved

Binding of the Books

The publications most closely allied to the needs or interests of the indexer are bound in volumes about one and one-half inch thick, which means one volume annually in a monthly, and four volumes annually in a weekly paper. The annual volumes are lettered on the back with the name of the publication and the year, as shown in Fig. 1 for MACHINERY, 1912. Quarterly volumes are marked with the name and year, but have an affix of the quarter in which they start, as *Iron Age*, 1912-2, meaning the volume of *Iron Age* beginning with April, 1912. The including of advertising matter is optional, but it has very little value to the individual aside from its historical interest. An extra blank sheet is inserted at the beginning of each month on which the printed index of that issue and small scraps from various sources are pasted. Binding and lettering in gold, complete with a three-quarter leather back costs about $2 per volume; and this also includes the re-numbering required when a paper starts its year with some other month than January. Each volume starts with page one, and the pages are numbered consecutively through both the editorial and advertising pages. Other publications which are not considered of sufficient value to warrant binding are clipped by cutting out entire pages with a sharp knife as near as possible to the inner edge; and they are then trimmed, perforated and bound in a 4-inch Tengwall binder. The pages are consecutively numbered and on the back of each volume is stuck a label marked "Scrap Book" and dated for the year, as shown in Fig. 2.

Starting an Index

It has been said that the beginning of all things is hard, but the beginning of a card index is surprisingly simple. After choosing some general subjects for the main titles as Shop Practice, Gearing, Metals, Press Work, Machinery, Automobiles, etc., a number of letter size envelopes are marked with these titles. Then small slips of paper ½ by 5 inches in size, are cut and each article of interest is listed on one side of an individual slip. The main title, as Gearing, is written on one side, and the other side is marked with the title of the article, the page number, volume symbol and date as 48-M-13, "Practical Form of Skew Bevel Gear Tooth." These slips are then placed in their various main title envelopes, and divided into such sub-titles as may be found desirable. No attempt should be made at this time to lay out definite lines of classification, as the subsequent necessity of adding subjects will simplify the final arrangement. An entire volume may be indexed in this way before entering the articles on the cards; and then by spreading out all the slips of a main title, a comprehensive view is obtained for guidance in making out an intelligent arrangement of titles and sub-divisions.

Another way that has been found to take less time, but which requires more experience, is to use cards for the main titles and add the page number, volume symbol, date and subject directly. However, as the marking of the cards must be done with a pen (a typewriter does not do good enough work to pay for the time occupied in inserting the cards) and as most of us do not write well enough, it will be found that the expense of reprinting an entire card or sub-dividing for changes more than makes up for the time spent in writing out the slips. For a small private index, standard 3 by 5 inch cards will be satisfactory, while for office use, 5 by 8 inch vertical cards may be used.

Sub-divisions by Color

Sub-divisions by color can be used for a strictly technical index, but for general purposes a white card is best. Where the color system is used, the following suggestion may be of value: Blue for all theoretical information, "How to

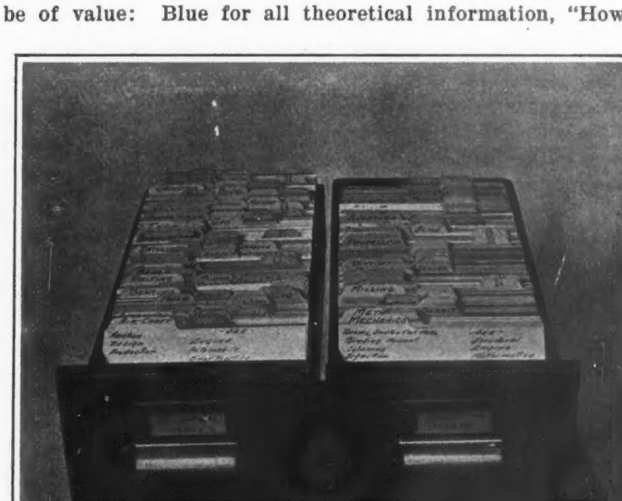


Fig. 3. Complete Card Index ready for Use

* For additional information on this subject, see also "Filing Articles and Data," published in MACHINERY for August, 1913, and other articles there referred to.

† Address: 45 Maplewood Ave., Bridgeport, Conn.

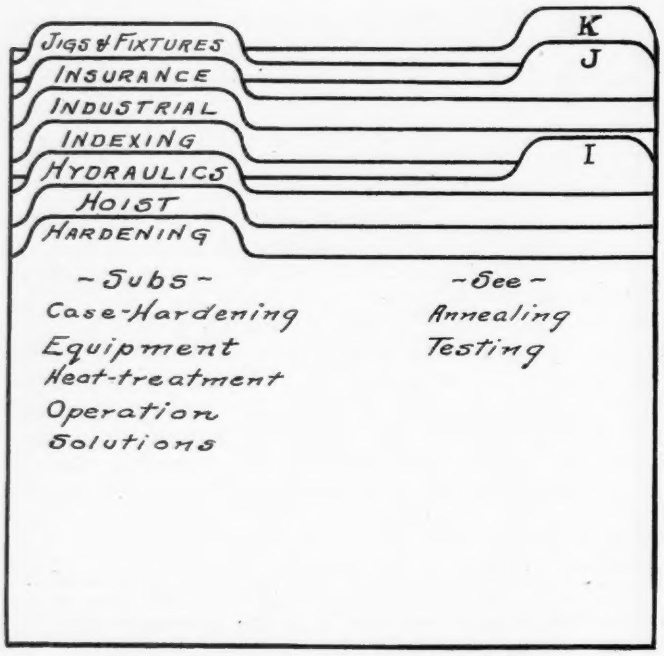


Fig. 4. Arrangement of Main Title Cards in Index

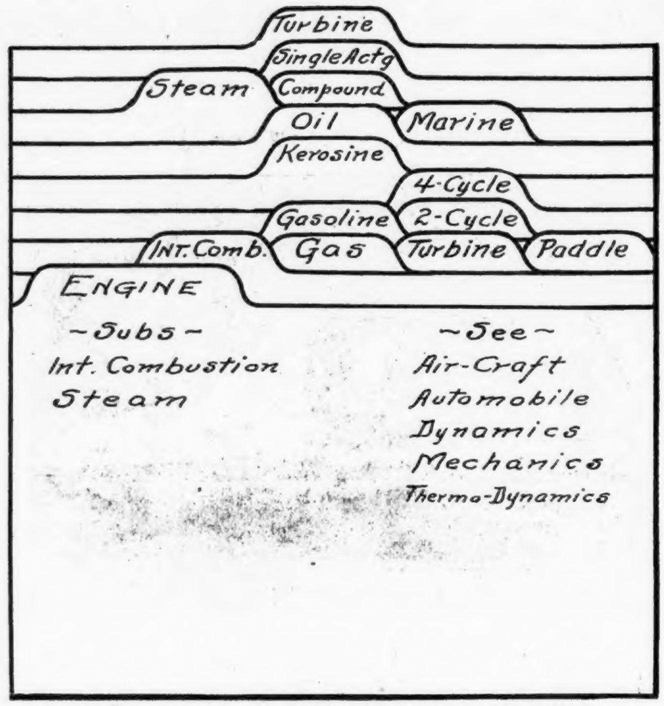


Fig. 5. Arrangement of Sub-title Cards for Card Index

figure it out," formulas, charts, designs, data, etc.; salmon for all practical information, "How it is done," production operations, recipes, methods in use, construction details, etc.; white for all general information on industrial matters, law, patents, tariff, etc.; buff may be used as a fourth color for denoting articles pertaining to a subject of especial interest. For instance, a man interested in production systems could index every article having any bearing on this subject on buff cards, even though both the main and subtitle did not show it. In a recent article describing the heat-treatment of blanks before machining, a very simple and effective routing system was explained, and by having the article indexed on a buff-colored card, this fact would have been recorded. The colored cards are filed under the same system as the white, but make the subject more readily accessible.

Main title cards are arranged alphabetically behind each other, and only the left "third" of a set divided into three tabs is used for this purpose, allowing for expansion of the index without alteration. These cards, as their name implies, are of prime importance; and they are used for subjects which are not directly related to one another, the arrangement of the cards in the file being shown in Fig. 4. The remaining space on the cards to the right of the tabs on the main title cards is used for the tabs of the sub-title cards, as shown in Fig. 5. The sub-divisions follow in the order of their position from the main title card; all subjects relating to a main title are alphabetically arranged behind each other, and the sub-title cards of each division show on the right, behind the main title card for that division. An alphabetical index is used as a general guide for subjects which do not warrant individual title cards, and such an index is made on the right-hand tab of the sub-title cards, the letters appearing behind each other as shown in Fig. 4.

Symbol System

The cards are ruled with columns for the page and symbol, but no printed heading for the column is required as it quickly becomes habitual to look in the proper column. Any convenient symbol system will do, providing it is not confusing or complicated. The advantage of these particular symbols is the graphic correlation which exists between the article, the publication in which it appeared and the year of publication. M = MACHINERY; IA = *Iron Age;* AM = *American Machinist;* EN = *Engineering News;* SB = *Scrap Book.* These symbols are entered for each article, in the second column on the card, as shown in Fig. 6.

Gearing - Bevel - Design		
48	M-10	Derivation of Formulae
531	IA-10-3	Diagram for finding Cutter
571	AM-10-2	Table of Dedendum Angles
631	M-11	Long Addendum
902	SB-11	Intermittent Motion

Fig. 6. Form of Cards used, showing Page Number, Symbol, Date of Publication and Title of Article

Cross Reference

When an article pertains to more than one subject, it is indexed under the title to which it is primarily allied and cross reference is made to the other titles. For example, an article on stop-screws which appeared in a recent publication was indexed under Machine Design Details, but Lathe, Planer, Milling Machine and Shaper, to all of which machines it could be applied, are cross references to Machine Design. This avoids bulkiness and superfluous work, making duplication of cards almost unnecessary. The idea will be readily understood by referring to Figs. 4 and 5.

Educational Value

Few of us seem to have time to do more than glance through the current literature relating to our own particular work, with perhaps the occasional reading of an entire article. We look over the titles and subconsciously remember, when the information is required, that some particular paper contained it—sometimes we even find it without difficulty. But while this is apparently economical as regards time, there are many instances when memory fails us, and then too, it crowds our mind with a vast amount of unprofitable material, leaving little space for the more important matters in hand. With a good index system it is necessary to read enough of every article to make possible its intelligent listing under the proper title, after which the entire subject may be dropped until it is needed, although the systematic reading serves to stimulate brain activity and broaden the reader's viewpoint.

Summary

In these days of modern methods and special machines, no man in the manufacturing business can keep up-to-date without the help of at least one technical publication; but the simple receiving of the paper with a casual glance through its pages is almost as useless as not having it at all. It follows that if we are to benefit by the experience of others in the field, it becomes almost impossible

to get along without some definite means of finding the desired information. The foregoing system is an adaptation of the one used in the United States Patent Office, and in its present simplified form it is easy to handle, develops rapid and convenient classifications and gives a sense of pride in accomplishment to the indexer. After the system is started it takes only a few hours every month to read and classify the articles, the pages of which are temporarily numbered in pencil for this purpose.

* * *

A NEW COMPETITOR OF ACETYLENE

BY J. F. SPRINGER*

The gases commonly employed in autogenous welding and cutting are oxygen, acetylene and hydrogen, all of which are expensive products. The average cost of oxygen throughout the United States is probably not less than $0.025 per cubic foot measured at atmospheric pressure; the average cost of acetylene probably ranges from $0.0075 to $0.01 per cubic foot; and the cost of hydrogen may safely be placed at about the same figure. Apparently no one has yet devised a system of oxygen manufacture that will enable this gas to be inexpensively produced. However, there appears to be a likelihood of heavy reduction in the cost of the fuel gas used in autogenous welding—not through a reduction in the cost of acetylene or hydrogen, but through the discovery of an adequate substitute for these gases. This substitute is a semi-natural gas obtained from the waste gas from oil wells, and is known as "gasol." It can be produced at about $0.001 per cubic foot, and its heating capacity is even greater than that of acetylene. Other things being equal, this gas selling for $0.0008 to $0.001 per cubic foot should have a considerable advantage over acetylene or hydrogen selling at $0.008 to $0.01—ten times as much.

RELATIVE VALUES OF GASES USED FOR WELDING AND CUTTING

Name of Gas	Cubic Feet of Oxygen required to burn one Cubic Foot	Heat Value in B. T. U. per Cubic Foot	Cost of 1000 B. T. U.
"Gasol".......	2	2300	$0.00162
Blau Gas. ...	2	1800	$0.00213
Acetylene	1½	1500	$0.00217
Hydrogen.....	2	500	$0.008

Machinery

Note: The above figures are based on the following prices: oxygen, 1½ cent per cubic foot; "gasol," 10 cents per pound; blau gas, 10 cents per pound; carbide, $70 per ton; and hydrogen, 1 cent per cubic foot.

In addition to the advantage in price, there is an economy in handling this new fuel gas. It is collected at the point of origin and compressed into liquid form, the liquid gas being shipped to the user in a suitable steel container. As the weight of the liquid gas in a container is equal to the weight of the container, an economy is effected in transportation costs. The gas issuing from the oil well, which is collected and compressed into the liquid form, is of variable composition, containing various percentages of hydro-carbon gases. The constituents of a typical sample of the crude gas as collected at the oil well include gases known as methane, hexane, butane, propane, and ethane mixed with more or less water and vapor. These constituents of the crude gas may be liquefied by the application of various amounts of pressure, the temperature remaining the same; or they may be brought to the liquid form by reductions in temperature, when the pressure remains constant.

All the gases with the exception of methane may be liquefied by the application of a moderate pressure under ordinary temperature conditions. But at 10 degrees F. it requires a pressure of 2700 pounds per square inch to liquefy methane, and this is obviously beyond commercial possibilities. At the maximum temperature which the gas will encounter during transportation, the pressure necessary to bring about the liquefaction of methane is impractical. The expense of the container would either be prohibitive or there would be a constant danger of the container exploding. These considerations make it necessary to eliminate the methane from the crude gas before it is liquefied, and as the heating value of methane is considerably below that of hexane, butane, propane or ethane, the elimination of the methane results in the production of a residual gas of higher heating value. However, the heating value of methane is not to be despised, and this gas is used in the locality where the residual gas is liquefied.

By applying a pressure of from 850 to 900 pounds per square inch to the residual gas at ordinary temperature, the gas will be brought to the liquid condition. This pressure can be readily obtained in practice and the cost of containers which will safely withstand the pressure of the gas is not excessive. The liquid gas has a specific gravity of about 0.5, or one-half that of water. One quart of the liquid weighs about 1 pound and produces approximately 10 cubic feet of gas. The containers in which the gas is shipped weigh approximately 100 pounds and have a capacity for 100 pounds of the liquid; accordingly, they hold approximately 1000 cubic feet of gas, which has a total heating value of about 2,000,000 B. T. U.

Natural gas requires an unusually large amount of oxygen for its combustion, but the gas evolved from the "gasol" liquid contained in the cylinders requires still more oxygen for its complete combustion. As a result, it will be evident that the burner of the welding torch must be designed to deliver a higher amount of oxygen relative to the fuel gas than is the case where acetylene is used. At first thought, it may appear that the relatively higher consumption of oxygen will largely offset the advantage of the lower cost of the fuel gas. This is not the case, however, as less of the liquid gas is used to do a given amount of work because its heat value is relatively higher than that of acetylene. A further economy would also be effected through saving the first cost and maintenance expense of an acetylene generating plant. In the event of this substitute for acetylene finding wide application, the manufacturers of cutting and welding equipments would not be seriously affected, as essentially the same type of apparatus could be used. No doubt it would be necessary to make certain modifications in design, a case in point being in respect to the relative cross-sectional areas of the oxygen and gas ducts in the torch, but aside from changes of this nature, the welding and cutting of metals with "gasol" would be the same as when acetylene is used.

* Address: 618 West 136th St., New York City.

* * *

MATERIALS OF ENGINEERING CONSTRUCTION

The materials of engineering construction will receive special attention in the proceedings and discussions of the International Engineering Congress to be held in San Francisco, September 20-25. The field will be treated under eighteen or more topics, covering: timber resources; preservative methods; brick and clay products in general; life of concrete structures; aggregates for concrete; water-proofing; volume changes in concrete; world's supply of iron; life of iron and steel structures; special steels; status of copper and world's supply; alloys; aluminum; testing of metals in full size members and in structures. About twenty-five papers are expected for the volume to be prepared by authors representing five different countries. The list of authors includes many of the most eminent names in this field of engineering work throughout the world. For further information, address W. A. Cattell, secretary, 417 Foxcroft Bldg., San Francisco, Cal.

* * *

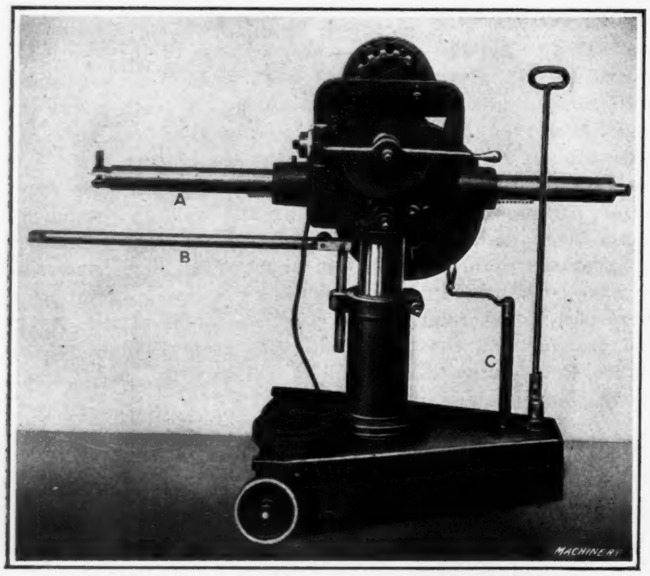
Some tradenames eventually become regarded as legitimate words and are recognized as parts of the language. A well-known example is "kodak," a term that has become generally used to designate a small, light camera. A type of trade name that has become quite popular in the past few years is that ending with "co," an example of which is "Mesco," being the initials of the name with the ending "co" of the Manhattan Electrical Supply Co. The obvious advantages of this form of trade name are the ease with which it can be coined and the degree of identification afforded.

A "MECHANICAL GUINEA"

The "guinea" in the industrial world is a willing laborer to whom are assigned the rough, hard jobs that trained men despise. The aim of efficient shop management should be to eliminate as many of the "guinea" jobs as possible by providing power-driven machines for doing them. It is not wise to pay machinists forty cents an hour to do by main strength what an electric motor may be made to accomplish at a hundredth of the cost.

In the building of machine tools, the fitting of heavy slides is a task requiring both skill and muscle—skill for the actual fitting and muscle to move the slides back and forth. On many fitting jobs it is necessary to employ two men, as the strength of one is insufficient. One-fourth their time and three-fourths of their energy is expended in moving the slides back and forth to show by red-lead markings where the high spots are. A power-driven machine for reciprocating these slides releases one man for other work and increases the production of scraped surfaces by the other.

The Lucas Machine Tool Co., Cleveland, Ohio, has provided two electrically driven machines for reciprocating tool-slides when being scraped in, known as "mechanical guineas," one of which is shown in the illustration. It comprises a heavy triangular base mounted on three wheels and supporting a column on top of which are mounted an electric motor and the horizontal ram *A*. The machine is set up in front of the rail on which a slide is to be fitted, the brace *B* being placed between the rail and the column and the ram connected to the slide. When adjusted, the screw *C* is turned down to lift



Lucas "Mechanical Guinea" for reciprocating Machine Tool-slides in Process of Fitting

the weight off the front wheel and hold the machine in position. The ram may be traversed by hand, using a crank, or by power. When the desired stroke has been adjusted by hand, the reversing stops are set and the motor is started.

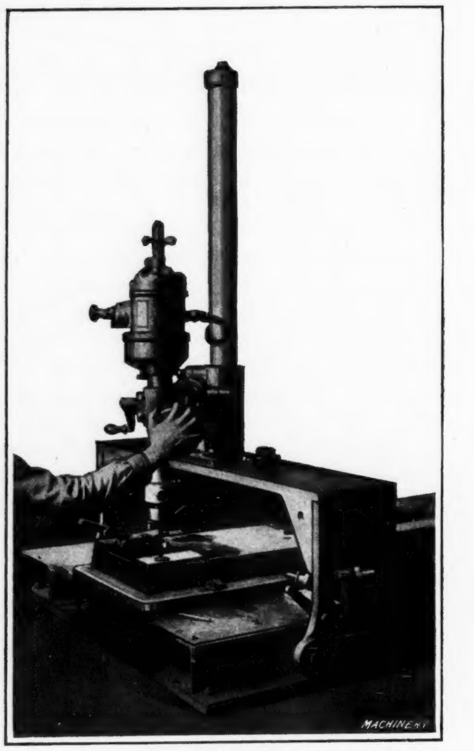
One man can, with the aid of the machine, scrape and fit the heaviest boring machine slides, such as table and saddle, saddle and bed, etc. While the machine is not intended to be a jacking or wearing-down device, it nevertheless may be used effectively to reduce the amount of scraping by wearing down the inequalities. Another advantage due to the use of power is that the gibs can be set up much closer than would be possible if moved by hand, and a more intimate bearing of the opposing surfaces is secured.

* * *

In order to gain more daylight time, the industries of Detroit, Mich., have been placed on eastern standard time, all clocks having been pushed ahead one hour May 15. Cleveland adopted the eastern standard time about one year ago. It seems unfortunate that the cities of the Middle West cannot hold to central standard time. The confusion resulting from a difference of one hour between local timepieces and railroad time causes many travelers to miss train connections.

UNUSUAL APPLICATION OF PORTABLE ELECTRIC DRILL

When the boring of holes in the bases of pumping machinery does not warrant the use of a large radial drilling machine, Charles S. Lewis & Co., St. Louis, Mo., use a portable electric drill of the type manufactured by the United States Electrical Tool Co., Sixth Ave. and Mount Hope St., Cincinnati, Ohio. A platform is provided upon which the various sized pump bases may be set up, and a carriage high enough to clear the largest base casting runs on this platform. The carriage supports a United States type GF radial drill, and clamps hold the carriage rigidly in place during the drilling operation. After all the holes have been drilled, an Errington tapper is substituted and the holes are tapped. The portable radial drill is provided with two speeds; the column is made heavy and the radial arm is of special length to cover the requirements of this work.



Use of United States Portable Electric Drill on Pump Base Castings

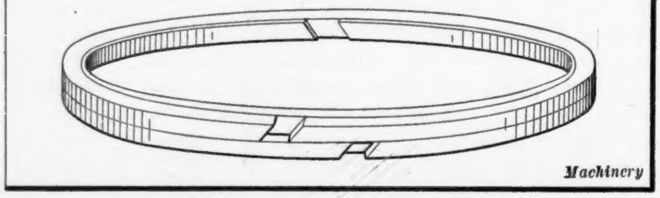
* * *

TRIPLE ECCENTRIC PISTON RING

A triple eccentric piston ring for automobile, marine, motorcycle and steam engines, air compressors, pumps, refrigerating machine, etc., has been put on the market by the Peerless Piston Ring Co., 91-107 Lafayette St., Newark, N. J., which has some features of interest to those who know the difficulties of making "leak-proof" piston rings.

The new ring is of the composite type which, when assembled, has a broad inner ring and two narrower rings outside, in contact with the walls of the cylinder. The inner ring serves the double purpose of expanding the outer rings and forming a seal to the joints. Both the inner and outer rings are of the eccentric type, the thick part of the inner ring being placed next to the thin part of the outer ring so that the assembled ring is concentric throughout. The joints in all are cut in the thin parts. The outer rings are held in a fixed position relative to the inner ring by a pin set in the latter, which can be seen between the two joints in the outer rings.

A study of this construction shows that it is theoretically "leak-proof." This ring prevents the gas or steam which gets beneath the ring in the piston ring groove from escaping through openings in the ring on the exhaust side. The double construction effectually seals all joints in the rings.



Peerless Triple Eccentric "Leak-proof" Piston Ring

ORGANIZING A NIGHT FORCE

The paper on organizing a night force read by Harold C. White at the recent meeting of the National Machine Tool Builders' Association in Atlantic City touched a vital subject to concerns whose normal capacity is exceeded by the demand for its product. The average plant is built and organized to turn out a maximum production with a full force working eight, nine, or ten hours a day. To exceed this production, it is necessary to run overtime or organize a night shift. Either is undesirable, and is avoided by good managers whenever possible. When men are required to work two or three hours overtime four or five nights a week, the production will increase for a few days and then it will begin to drop until in some cases it falls to the normal production when the men are working full time only. The cause is simply that the men become tired out and no longer have the energy and initiative to work with accustomed celerity. Overtime work then is profitable only for short periods, as an emergency measure. If the demand for product is such that overtime would have to be worked for many weeks or months, it is far better to organize a night force. How can this be done most efficiently?

Mr. White pointed out that labor employed at night is usually employed at a disadvantage. In the first place, it is difficult to obtain first-class workmen for a night shift. The normal skilled workman capable of holding a job prefers, of course, to work days, and usually has no difficulty in holding a day job. The men available for night work therefore are the comparatively unskilled or inefficient mechanics who are generally dropped when industrial conditions require contraction of the working force. A second difficulty is that of properly feeding men working at night. Night hours upset the domestic routine, and workmen are likely to be poorly nourished when working nights. For this reason, it seems advisable to furnish hot coffee and other refreshments in the middle of the night shift. It is not only desirable to do this, but necessary for their welfare; it is also necessary to pay a night shift somewhat higher wages. The amount of extra wages appears to range from ten to twenty per cent.

A third disadvantage of working nights is the difficulty of obtaining sufficient sleep. Those who work at night must sleep through the day, but street noises and the light make it almost impossible for nervous men to obtain an adequate amount of sleep, and they soon break down because of the lack.

It was pointed out in the discussion that a shop requiring to organize a night force can employ a number of its best workmen in the night shift. These men, having steady employment, will not seriously object to the night shift for a few weeks, provided they are paid higher wages and are accorded other favors customary in such cases. These men may be used as a training force for the night shift, and may be placed in those positions where the best work and most careful inspection are necessary. It is possible also to arrange the hours of the day and night forces so that the night force will be relieved at a time when it is possible to obtain a few hours sleep in the very early morning, before the noises of the streets become too loud. Thus, in a plant working nine-hour shifts, the day shift begins at 7 and quits at 5; the night force goes on immediately and quits at 2 in the morning. Men leaving work at this time can get a normal amount of sleep before noon.

Mr. White pointed out that one reason why a night force was likely to turn out bad work is that the machinery, being used twice as much as usual, deteriorates twice as fast and, of course, requires twice as much repair work. The tendency in times like these is to neglect repair work and the consequence is that the equipment goes way below par long before it would if used only by a day shift.

The conclusions are that to operate a night shift efficiently it is necessary to employ some highly skilled men, to pay wages above the day rate, to supply refreshments, to carefully inspect machinery and tools, and to make all needed repairs promptly. Efficient lighting is also an important factor. It has been shown that highly efficient lighting does wonders in raising the standard and quantity of the product.

FINDING CHANGE GEARS FOR HOBBING SPIRAL GEARS*

BY GEORGE W. FELTON†

The degree of uncertainty resulting from the use of the usual methods employed for finding suitable change gears for hobbing spiral gears, and the loss of time arising from this cause, led the writer to set himself the task of developing a more satisfactory method. It is not within the scope of this article to describe the several formulas for finding change gears which are supplied by the different makers of hobbing machines, except to say that the best and latest of these leaves something to be desired. After making a careful study of the subject, the method of procedure described in the following was devised, and this method has been found satisfactory in every way. It is not only a considerable time-saver, but the opportunity offered for selecting the best of several combinations of gears is worth a great deal when extreme accuracy is desired. Furthermore, the calculation is of such a simple character and so little time is required to reach a satisfactory solution that the method should appeal to all hobbing machine operators.

Formulas for Change Gears

The required change gear ratio is dependent upon whether the hob is of the same hand as the gear which is to be cut or of the opposite hand. Herewith are given the fundamental formulas for the two conditions:

For a hob of the same hand as the gear, the following formula is used:

$$\frac{\text{Lead} \div \text{feed}}{\text{Lead} \div \text{feed} - 1} \times \frac{60 \times \text{number of threads in hob}}{\text{number of teeth in gear}} = \frac{\text{product of drivers}}{\text{product of driven gears}} \qquad (1)$$

For a hob of the opposite hand to that of the gear, the following formula is used:

$$\frac{\text{Lead} \div \text{feed}}{\text{Lead} \div \text{feed} + 1} \times \frac{60 \times \text{number of threads in hob}}{\text{number of teeth in gear}} = \frac{\text{product of drivers}}{\text{product of driven gears}} \qquad (2)$$

The preceding formulas give a true statement of the conditions which exist when we have to hob a spiral gear of any kind. If, however, these formulas are strictly followed out in the way in which they are given, *i.e.*, by selecting a definite feed and dividing it into the lead, it is very likely that prime numbers will be encountered, in which case all of the labor and time that has been spent in making the calculation is lost, and it is necessary to select another value for the feed and begin the calculation over again. The following method of solving the problem enables one to obtain suitable change gears in a few minutes, and with only a slight mental effort. The following notation is used:

L = lead of gear spiral in inches;
N = number of teeth in gear to be cut;
T = number of threads in hob;
F = feed per revolution of gear being cut;
R = number of times F is contained in $L = \dfrac{\text{lead}}{\text{feed per revolution}}$.

Using the preceding notation Formula (1), for a hob of the same hand as the gear to be cut, may be expressed as follows:

$$\frac{R}{R-1} \times \frac{60\,T}{N} = \frac{\text{product of drivers}}{\text{product of driven gears}} \qquad (3)$$

Similarly, Formula (2) for a hob of opposite hand to that of the gear which is to be cut may be expressed in the following form:

$$\frac{R}{R+1} \times \frac{60\,T}{N} = \frac{\text{product of drivers}}{\text{product of driven gears}} \qquad (4)$$

* For additional information published in MACHINERY relative to the gearing of hobbing machines for generating spiral gears, see "Differential Mechanism on Gear Hobbing Machines" by W. Natisch, May, 1912; and "Calculating Gears for Generating Spirals on Hobbing Machines" by Glenn Muffly, December, 1911.

† Chief Designer, New Process Gear Corporation, Syracuse, N. Y.

Method of Procedure

The method of procedure is as follows: First, look up the logarithm of the lead of the gear which is to be cut. Second, decide upon an approximate feed per revolution of the gear blank, which is suitable for the work; and then select a value of the feed F in Table I, which is of approximately the same value. The logarithm of $\frac{1}{F}$ will be found opposite this value of the feed in the right-hand column of the table. Third, add the logarithm of $\frac{1}{F}$ to the logarithm of the lead, the result being the logarithm of R. Fourth, take the resulting logarithm and find a value of the logarithm of R in Table II which is of approximately the same value. If such a value of the logarithm of R is found, the corresponding value of R will be obtained in the column to the left of the logarithm in Table II. If a sufficiently close value cannot be found, it will be necessary to select another value of the feed F in Table I, which is close to the original value, and then go through the same method a second time. As the process is simply one of addition, a dozen or more trials may be made very quickly. It should be borne in mind that the sum of the logarithm of the lead and the logarithm of $\frac{1}{F}$ should correspond with the value of the logarithm of R found in Table II to the fourth decimal place, or the values should at least be very nearly equal. Table II is merely a table of numbers up to 1197, in which all numbers that are useless for this work have been omitted. The table provides for cutting spiral gears of all leads up to 39 inches, using a feed of about 1/32 inch per revolution of the gear blank. This table could, of course, be continued indefinitely.

Proof

$F \times R =$ lead cut;

$\frac{\text{Lead cut}}{\text{Correct lead}} = 1$ when perfect results are obtained.

Maximum tolerance should be between 1.001 and 0.999 for gears on shafts at right angles; or between 1.0001 and 0.9999 for gears on parallel shafts.

Example

Suppose it is required to cut a steel spiral gear with 41 teeth of 10 pitch, 45 degree spiral angle, and 5.7982 inch lead, for shafts at right angles, using a single-threaded hob of the same hand as the gear. Following the method of procedure which has been outlined: First, look up the logarithm of the lead and write it down several times in a horizontal row as shown in the following calculation. Second, decide upon a suitable rate of feed, which for steel will be about 0.025 inch per revolution of the gear blank. Next refer to Table I for a feed of approximately this value, and take several successive values of the logarithm of $\frac{1}{F}$. Third, add the values of the logarithm of the lead and the logarithm of $\frac{1}{F}$. Fourth, refer to Table II and find a value of the logarithm of R which is approximately equal to the sum of the logarithms already determined. The calculation is as follows:

Logarithm of lead	= 0.76329	0.76329	0.76329
Logarithm of $\frac{1}{F}$	= 1.58947	1.57209	1.55499
Logarithm of R	= 2.35276	2.33538	2.31828

The sum of the logarithm of the lead and the third value of the logarithm of $\frac{1}{F}$, comes sufficiently close to the logarithm of R, for $R = 208$.

$$\text{Then } \frac{R}{R-1} \times \frac{60\,T}{N} = \frac{208}{207} \times \frac{60 \times 1}{41} = \frac{24 \times 52 \times 60}{27 \times 46 \times 41} = \frac{\text{product of drivers}}{\text{product of driven gears}}.$$

The feed gears found in Table I to the left of the value of the logarithm of $\frac{1}{F} = 1.55499$ which was used, are $\frac{37}{83}$, and

TABLE I. FEED TABLES FOR GOULD & EBERHARDT TWENTY-FOUR INCH HOBBING MACHINE

For Machine with Simple Feed Gearing (Fixed Centers)					For Machine with Compound Feed Gearing				
Feed Gears		Feed per Revolution of Blank=F		Log. $\frac{1}{F}$	Feed Gear Ratio		Feed per Revolution of Blank=F		Log. $\frac{1}{F}$
Driver	Driven	Fraction	Decimal		Driver	Driven	Fraction	Decimal	
24	96	1/64	0.0156250	1.8061800	16	64	1/64	0.0156250	1.8061800
25	95	5/304	0.0164474	1.7839036	16	63	1/63	0.0158730	1.7993405
26	94	13/752	0.0172872	1.7622748	16	62	1/62	0.0161290	1.7923917
27	93	9/496	0.0181452	1.7412391	16	61	1/61	0.0163934	1.7853298
28	92	7/368	0.0190218	1.7207495	16	60	1/60	0.0166667	1.7781513
29	91	29/1456	0.0199176	1.7007634	16	59	1/59	0.0169492	1.7708520
30	90	1/48	0.0208333	1.6812412	16	58	1/58	0.0172414	1.7634280
31	89	31/1424	0.0217697	1.6621485	16	57	1/57	0.0175439	1.7558749
32	88	1/44	0.0227273	1.6434527	16	56	1/56	0.0178571	1.7481880
33	87	11/464	0.0237069	1.6251251	16	55	1/55	0.0181818	1.7403627
34	86	17/688	0.0247093	1.6071397	16	54	1/54	0.0185185	1.7323938
35	85	7/272	0.0257353	1.5894704	16	53	1/53	0.0188679	1.7242759
36	84	3/112	0.0267857	1.5720964	16	52	1/52	0.0192308	1.7160033
37	83	37/1328	0.0278614	1.5549965	16	51	1/51	0.0196078	1.7075702
38	82	19/656	0.0289636	1.5381501	16	50	1/50	0.0200000	1.6989700
39	81	13/432	0.0300926	1.5215408	16	49	1/49	0.0204082	1.6901961
40	80	1/32	0.0312500	1.5051500	16	48	1/48	0.0208333	1.6812412
41	79	41/1264	0.0324367	1.4889636	16	47	1/47	0.0212766	1.6720979
42	78	7/208	0.0336538	1.4729655	16	46	1/46	0.0217391	1.6627578
43	77	43/1232	0.0349026	1.4571428	16	45	1/45	0.0222222	1.6532125
44	76	11/304	0.0361842	1.4414815	16	44	1/44	0.0227273	1.6434527
45	75	3/80	0.0375000	1.4259693	16	43	1/43	0.0232558	1.6334685
46	74	23/592	0.0388514	1.4105951	16	42	1/42	0.0238095	1.6232493
47	73	47/1168	0.0402397	1.3953456	16	41	1/41	0.0243902	1.6127839
48	72	1/24	0.0416667	1.3802112	16	40	1/40	0.0250000	1.6020600
49	71	49/1136	0.0431338	1.3651828	16	39	1/39	0.0256410	1.5910646
50	70	5/112	0.0446429	1.3502480	16	38	1/38	0.0263158	1.5797836
51	69	17/368	0.0461957	1.3353997	16	37	1/37	0.0270270	1.5682017
52	68	13/272	0.0477941	1.3174198	16	36	1/36	0.0277778	1.5563025
53	67	53/1072	0.0494403	1.3059186	16	35	1/35	0.0285714	1.5440680
54	66	9/176	0.0511364	1.2912711	16	34	1/34	0.0294118	1.5314789
55	65	11/208	0.0528846	1.2766709	16	33	1/33	0.0303030	1.5185139
56	64	7/128	0.0546875	1.2621117	16	32	1/32	0.0312500	1.5051500
57	63	19/336	0.0565476	1.2475854	16	31	1/31	0.0322581	1.4913617
58	62	29/496	0.0584677	1.2330850	16	30	1/30	0.0323333	1.4771213
59	61	59/976	0.0604508	1.2185985	16	29	1/29	0.0344828	1.4623980
60	60	1/16	0.0625000	1.2041200	16	28	1/28	0.0357143	1.4471580
61	59	61/944	0.0646186	1.1896419	16	27	1/27	0.0370370	1.4313638
62	58	31/464	0.0668103	1.1751551	16	26	1/26	0.0384615	1.4149733
63	57	21/304	0.0690789	1.1606546	16	25	1/25	0.0400000	1.3979400
64	56	8/112	0.0714286	1.1461280	16	24	1/24	0.0416667	1.3802112
65	55	13/176	0.0738636	1.1315705	16	23	1/23	0.0434783	1.3617278
66	54	11/144	0.0763888	1.1169695	16	22	1/22	0.0454545	1.3424227
67	53	67/848	0.0790094	1.1023205	16	21	1/21	0.0476190	1.3222193
68	52	17/208	0.0817308	1.0876147	16	20	1/20	0.0500000	1.3010300
69	51	23/272	0.0845588	1.0728416	16	19	1/19	0.0526316	1.2787536
70	50	7/80	0.0875000	1.0579929	16	18	1/18	0.0555556	1.2552725
71	49	71/784	0.0905612	1.0430595	16	17	1/17	0.0588235	1.2304489
72	48	3/32	0.0937500	1.0280300	16	16	1/16	0.0625000	1.2041200
73	47	73/752	0.0970745	1.0128962	16	15	1/15	0.0666667	1.1760913
74	46	37/368	0.1005434	0.9976463	16	14	1/14	0.0714286	1.1461280
75	45	5/48	0.1041667	0.9822712	16	13	1/13	0.0769231	1.1139434
76	44	19/176	0.1079545	0.9667592	16	12	1/12	0.0833333	1.0791812
77	43	77/688	0.1119186	0.9510975	16	11	1/11	0.0909081	1.0413927
78	42	13/112	0.1160714	0.9352744	16	10	1/10	0.1000000	1.0000000
79	41	79/656	0.1204268	0.9192769	16	9	1/9	0.1111111	0.9542425
80	40	1/8	0.1250000	0.9030900	16	8	1/8	0.1250000	0.9030900

Machinery

feed per revolution is 0.0278614 inch.

The accuracy of the result is proved as follows:

$$\frac{\text{Lead cut}}{\text{Correct lead}} = \frac{208 \times 0.0278614}{5.7982} = 0.9993.$$

While this method was worked out especially for use in connection with the 24-inch Gould & Eberhardt hobbing machine, the principle involved could be readily adapted to any other make of gear hobber. The formula may be regarded as having two separate parts. The first part, *i.e.*, $\frac{R}{R-1}$ or $\frac{R}{R+1}$ which is the "accelerating" or "retarding" part, according to the hand of the hob, is not affected by the type of machine, but depends entirely upon the feed, the lead being fixed. The second part of the formula, *i.e.*, $\frac{60\,T}{N}$, which equals the $\frac{\text{product of drivers}}{\text{product of driven gears}}$ for hobbing spur gears, varies for different machines. The real problem amounts to finding a factor R which will avoid encountering prime numbers and still give a feed which is suitable for the material of which the gear is composed, and at the same time produce accurate work. The need for a close approximation will be evident to anyone who studies the matter.

TABLE II. VALUES OF THE FACTOR R AND LOGARITHM OF R

R	Log. R	R	Log. R	R	Log. R	R	Log. R	R	Log. R	R	Log. R	R	Log. R	R	Log. R
99	1.99563	189	2.27646	291	2.46389	+402	2.60422	530	2.72427	+670	2.82607	+832	2.92012	−1001	3.00043
−100	2.00000	−190	2.27875	−292	2.46538	−403	2.60530	531	2.72509	671	2.82672	−833	2.92064	+1007	3.00302
+104	2.01703	+194	2.28780	+294	2.46834	+405	2.60745	532	2.72591	−672	2.82736	+836	2.92220	−1008	3.00346
105	2.02118	195	2.29003	295	2.46982	406	2.60852	533	2.72672	+675	2.82930	−837	2.92272	+1014	3.00603
−106	2.02530	−196	2.29225	296	2.47129	407	2.60959	−534	2.72754	−676	2.82994	+840	2.92427	−1015	3.00646
+110	2.04139	+200	2.30103	−297	2.47275	−408	2.61066	+539	2.73158	+679	2.83186	−841	2.92479	+1022	3.00945
111	2.04532	−201	2.30319	+299	2.47567	+413	2.61595	−540	2.73239	−680	2.83250	+845	2.92685	1023	3.00987
−112	2.04921	+203	2.30749	300	2.47712	414	2.61700	+549	2.73957	+688	2.83758	846	2.92737	1024	3.01030
+114	2.05690	204	2.30963	−301	2.47856	415	2.61804	550	2.74036	689	2.83821	847	2.92788	1025	3.01072
115	2.06069	−205	2.31175	+304	2.48287	−416	2.61909	551	2.74115	−690	2.83884	−848	2.92839	1026	3.01114
116	2.06445	+207	2.31597	305	2.48429	+423	2.62634	552	2.74193	+696	2.84260	+850	2.92941	−1027	3.01157
117	2.06818	208	2.31806	−306	2.48572	424	2.62736	−553	2.74272	−697	2.84323	851	2.92992	−1032	3.01367
118	2.07188	209	2.32014	+315	2.49831	425	2.62838	+558	2.74663	702	2.84633	−852	2.93043	+1034	3.01452
119	2.07554	−210	2.32221	−316	2.49968	426	2.62940	559	2.74741	703	2.84695	+854	2.93145	1035	3.01494
120	2.07918	+212	2.32633	+318	2.50242	427	2.63042	560	2.74818	704	2.84757	−855	2.93196	1036	3.01535
121	2.08278	−213	2.32837	319	2.50379	+429	2.63245	−561	2.74896	−705	2.84818	+860	2.93449	−1037	3.01577
122	2.08635	+215	2.33243	−320	2.50515	−430	2.63346	−567	2.75358	+710	2.85125	−861	2.93500	+1044	3.01870
123	2.08990	216	2.33445	+322	2.50785	+434	2.63748	−568	2.75434	711	2.85186	+867	2.93801	−1045	3.01911
124	2.09342	−217	2.33645	323	2.50920	−435	2.63848	+574	2.75891	712	2.85248	868	2.93851	+1053	3.02242
125	2.09691	+219	2.34044	324	2.51054	+437	2.64048	575	2.75966	713	2.85308	869	2.93901	−1054	3.02284
−126	2.10037	220	2.34242	−325	2.51188	−438	2.64147	−576	2.76042	714	2.85369	870	2.93951	+1064	3.02694
+128	2.10721	221	2.34439	+328	2.51587	+440	2.64345	+580	2.76342	−715	2.85430	−871	2.94001	1065	3.02734
129	2.11058	−222	2.34635	329	2.51719	441	2.64443	581	2.76417	+725	2.86033	+873	2.94101	1066	3.02775
−130	2.11394	+224	2.35024	−330	2.51851	−442	2.64542	582	2.76492	−726	2.86093	874	2.94151	1067	3.02816
+132	2.12057	−225	2.35218	+332	2.52113	+444	2.64738	583	2.76566	+728	2.86213	875	2.94200	−1068	3.02857
133	2.12385	+230	2.36172	−333	2.52244	−445	2.64836	584	2.76641	729	2.86272	−876	2.94250	+1071	3.02978
134	2.12710	231	2.36361	+335	2.52504	+450	2.65321	−586	2.76789	730	2.86332	+884	2.94645	1072	3.03019
135	2.13033	−232	2.36548	−336	2.52633	−451	2.65417	+588	2.76937	731	2.86391	−885	2.94694	−1073	3.03059
−136	2.13353	+234	2.36921	+340	2.53147	+455	2.65801	589	2.77011	−732	2.86451	+890	2.94939	+1078	3.03261
+140	2.14612	235	2.37106	341	2.53275	−456	2.65896	−590	2.77085	+735	2.86628	−891	2.94987	1079	3.03302
141	2.14921	236	2.37291	342	2.53402	+459	2.66181	+594	2.77378	736	2.86687	+896	2.95230	1080	3.03342
142	2.15228	237	2.37474	343	2.53529	−460	2.66275	−595	2.77451	737	2.86746	−897	2.95279	−1081	3.03382
143	2.15533	−238	2.37657	344	2.53655	+464	2.66651	+602	2.77959	−738	2.86805	+899	2.95375	+1088	3.03662
144	2.15836	+242	2.38381	−345	2.53781	−465	2.66745	−603	2.78031	+740	2.86923	900	2.95424	−1089	3.03702
145	2.16136	243	2.38560	+350	2.54406	+468	2.67024	+608	2.78390	741	2.86981	901	2.95472	+1104	3.04296
146	2.16435	244	2.38738	351	2.54530	469	2.67117	609	2.78461	−742	2.87040	902	2.95520	1105	3.04336
147	2.16731	245	2.38916	−352	2.54654	−470	2.67209	610	2.78532	+747	2.87332	−903	2.95568	1106	3.04375
−148	2.17026	246	2.39093	+354	2.54900	+472	2.67394	611	2.78604	−748	2.87390	+912	2.95999	1107	3.04414
+152	2.18184	247	2.39269	355	2.55022	473	2.67486	−612	2.78675	+759	2.88024	−913	2.96047	−1108	3.04453
153	2.18469	248	2.39445	356	2.55145	474	2.67577	+615	2.78887	−760	2.88081	+923	2.96520	+1113	3.04649
154	2.18752	249	2.39619	−357	2.55266	475	2.67669	−616	2.78958	+767	2.88479	924	2.96567	−1114	3.04688
155	2.19033	−250	2.39794	+360	2.55630	476	2.67760	+620	2.79239	−768	2.88536	−925	2.96614	+1120	3.04921
−156	2.19312	+252	2.40140	−361	2.55750	−477	2.67851	−621	2.79309	+774	2.88874	+930	2.96848	1121	3.04960
+158	2.19865	−253	2.40312	+363	2.55990	+480	2.68124	+623	2.79448	775	2.88930	−931	2.96894	+1127	3.05192
159	2.20139	+255	2.40654	364	2.56110	−481	2.68214	624	2.79518	776	2.88986	+935	2.97081	−1128	3.05230
160	2.20412	−256	2.40824	365	2.56229	+483	2.68394	−625	2.79588	−777	2.89042	−936	2.97127	+1131	3.05346
161	2.20682	+258	2.41161	−366	2.56348	484	2.68484	+629	2.79865	+779	2.89153	+943	2.97451	−1132	3.05384
−162	2.20951	259	2.41329	+368	2.56584	485	2.68574	−630	2.79934	780	2.89209	944	2.97497	+1139	3.05652
+164	2.21484	260	2.41497	369	2.56702	−486	2.68663	+636	2.80345	781	2.89265	945	2.97543	−1140	3.05690
165	2.21748	−261	2.41664	370	2.56820	+492	2.69196	637	2.80413	782	2.89320	−946	2.97589	+1147	3.05956
−166	2.22010	+264	2.42160	371	2.56937	493	2.69284	638	2.80482	783	2.89376	+948	2.97680	−1148	3.05994
+168	2.22530	265	2.42324	−372	2.57054	494	2.69372	639	2.80550	−784	2.89431	949	2.97726	+1156	3.06295
169	2.22788	266	2.42488	+374	2.57287	495	2.69460	−640	2.80618	+792	2.89872	−950	2.97772	−1157	3.06333
170	2.23044	267	2.42651	375	2.57403	496	2.69548	+644	2.80888	−793	2.89927	+960	2.98227	+1159	3.06408
171	2.23299	−268	2.42813	376	2.57518	497	2.69635	645	2.80955	+798	2.90200	961	2.98272	1160	3.06445
−172	2.23552	+272	2.43456	377	2.57634	−498	2.69722	−646	2.81023	799	2.90254	−962	2.98317	1161	3.06483
+174	2.24054	−273	2.43616	−378	2.57749	+506	2.70415	+648	2.81157	800	2.90309	+968	2.98587	−1162	3.06520
175	2.24303	+275	2.43933	+384	2.58433	−507	2.70500	649	2.81224	−801	2.90363	969	2.98632	+1175	3.07003
176	2.24551	−276	2.44090	−385	2.58546	+510	2.70757	650	2.81291	+803	2.90471	−970	2.98677	−1176	3.07040
177	2.24797	+279	2.44560	+387	2.58771	511	2.70842	−651	2.81358	804	2.90525	+975	2.98900	+1183	3.07288
−178	2.25042	−280	2.44715	−388	2.58883	512	2.70927	+656	2.81690	805	2.90579	−976	2.98944	1184	3.07335
+182	2.26007	+284	2.45331	+390	2.59106	−513	2.71011	657	2.81756	−806	2.90633	+979	2.99078	−1185	3.07371
183	2.26245	285	2.45484	391	2.59217	+516	2.71264	−658	2.81822	+816	2.91169	−980	2.99122	+1188	3.07481
184	2.26481	286	2.45636	−392	2.59328	517	2.71349	+663	2.82151	−817	2.91222	+986	2.99387	1189	3.07518
185	2.26717	287	2.45788	+395	2.59659	−518	2.71432	664	2.82216	+819	2.91328	987	2.99431	−1190	3.07554
186	2.26951	288	2.45939	−396	2.59769	+527	2.72181	665	2.82282	−820	2.91381	−990	2.99563	+1196	3.07773
187	2.27184	289	2.46089	+399	2.60097	528	2.72263	666	2.82347	+825	2.91645	+999	2.99956	−1197	3.07809
188	2.27415	290	2.46239	−400	2.60206	+529	2.72345	−667	2.82412	−826	2.91698	1000	3.00000	......	....

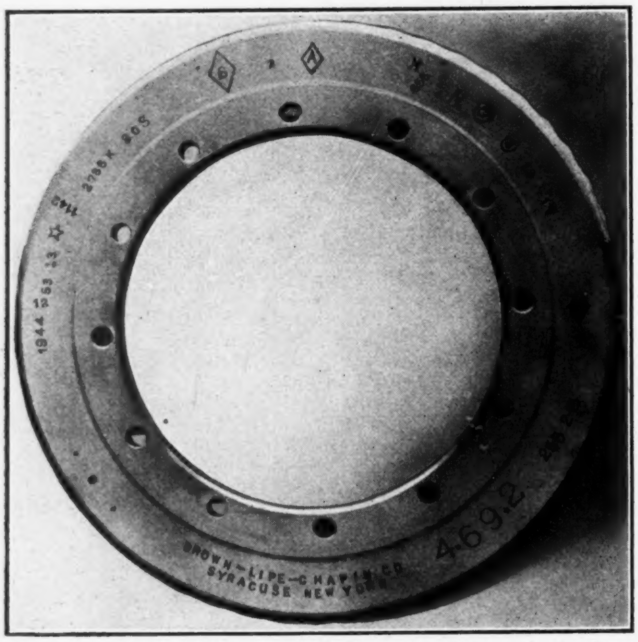
Machinery

Note: Numbers preceded by a minus sign may be used if the hob is of the same hand as the work, and no prime numbers will appear. Numbers preceded by a plus sign may be used if the hob is of opposite hand to the work, and no prime numbers will appear. Numbers preceded by neither a minus nor a plus sign may be used in either case, and no prime numbers will appear.

THOROUGH INSPECTION OF WORK

BY CHESTER S. RICKER*

It has always been a problem with manufacturers of bevel gears for automobiles to properly check back over the process of manufacture, in case something should go wrong with the work while in process, which afterward results in an epidemic of broken, noisy or badly worn gears. When a firm is striving to give its customers the best possible material and workmanship, and is at the same time producing parts in large quantities, it is a very important thing to be able to check back in case of trouble. It is also important to be in a position to fix the blame on the right man when complaints are received. All these requirements are fulfilled by the very complete inspection system which is in use at the plant of the Brown-Lipe-Chapin Co. of Syracuse, New York. An examination of the ring-bevel gear illustrated herewith, which has not been retouched, will give one a good idea of the complete inspection record which is available whenever a gear is returned. It is a complete history of the gear from the engineering department to the user. The abbreviations give the history as follows:



Automobile Ring-bevel Gear made by Brown-Lipe-Chapin Co., showing Thorough Inspection that is made

Starting with the company's name and going clockwise, you come to three round marks. The large one in the center is the impression made by the Brinell ball-test for hardness, and the two punch marks on each side of it are the buyer's inspector's O. K. as well as the O. K. for the toughness of the core.

1944 is the blueprint number from which the gear is made.

12 indicates the back-angle of the gear.

53-13 indicates the number of gear teeth and the gear ratio.

The star indicates that the gear was cut by the night shift.

1142 is the time-clock number of the man who cut the teeth.

2786K indicates the order number on which the gear was made, and in this case that it goes to Weston-Mott Co.

20S means that the cutter was for a 20-degree special tooth.

6 (inside of a diamond) indicates that the gear blank was heat-treated before it was machined.

7 is the time-clock number of the man who O. K.'d the blocking of the teeth.

A (inside of a diamond) indicates that the gear blank was annealed before machining.

K indicates the inspection of the holes, and that they were found satisfactory.

655 is the time-clock number of the man who performed the first operation in the machine shop, consisting of boring out the center hole and facing the back.

40 is the time-clock number of the inspector who passed on the first machining operations.

N designates the character and class of the steel used.

G (inside of a circle) designates the firm who made the forging blank.

39 (inside of an ellipse) is the number of the inspector who passed on the running-in of the gearing.

13 is the number of the inspector who passed on the second operation.

11 is the number of the man who performed the second machining operation of turning the face and back-angle surfaces.

C1 (inside of a diamond) indicates the chief inspector's O. K. on lots of 100.

2-15 indicates the month and year in which the gear was made.

255 is the number of the man who drilled the gear.

4.69.2 is the heat-treating number, and indicates the position in the pot, the location of the pot in the furnace, and the number of the furnace.

A chain is only as strong as its weakest link, and in this factory every means is used to determine where the "weak link" lies so it can be eliminated.

* Address: 1201 State Life Bldg., Indianapolis, Ind.

* * *

DROP-FORGING DIES*

The making of the dies for drop-forgings is a matter of first importance. Each design or piece has to be given individual attention in order to promote ease of operation, free flow of the metal while forging, and accuracy in form and dimensions. To permit the easy removal of the forgings from dies, a draft of about seven degrees is usually allowed on the sides or vertical walls, although in some shapes it may be more or less than seven degrees. Ordinarily the draft is secured by adding metal, but where the forging is not to be finished to any particular dimension, or if the metal could be spared at that point, it is sometimes taken off. The allowance for shrinkage is usually 3/16 inch to the foot, but practice varies.

For economical reasons, dies are sometimes made with only a single forging impression; this reduces the first cost of the tool, but the forcing of the hot metal into its final shape without any preliminary operation may sometimes result unsatisfactorily, since it is likely to set up stresses or add to any that may have existed in the bar and thereby establish a center for crystallization when the forgings are in use. By making the dies with at least two impressions, one being merely auxiliary to partially shape the piece, and having the corners, if any, well rounded, to permit a gentle flow of the metal in the dies, and the other impression to give the final shape, the likelihood of any additional stress being set up is diminished, and the life of the dies is lengthened.

For the making of plain pieces, one set of dies is usually sufficient, but in many of the more complicated parts, such as a crankshaft having three or more throws not in the same plane, two or more sets of dies are required, one for each separate operation. Frequently, the intermediate operations may be performed in the press, which is normally an auxiliary of the drop-hammer or it may be desirable to resort to first principles and employ the blacksmith, who is yet, and probably always will be, a very important factor in the working of wrought metals. The variety of shapes that can be made by this process is almost unlimited, though some would require so many operations as to make the cost prohibitive. But where the parts are required in large quantities, this difficulty may be overcome in a measure, even though three or more operations may be required to produce them. Very thin pieces, or those that are thin with heavy sections at intervals, are among the difficult shapes to produce, because of the rapid cooling of the parts in the dies, which prevents the reduction to size without reheating. Such pieces, therefore, are more costly to drop-forge than those of equal weight but more regular in outline and of greater thickness.

* Extract from paper by A. M. Tilton, read at the Atlantic City, N. J., meeting of the National Machine Tool Builders' Association, May 20-21, 1915.

* * *

It has been quite conclusively shown that 25 per cent of the yearly coal bill of a factory depends directly upon the skill of the fireman. In New England a man will burn on an average from $40 to $50 worth of coal a day in a 500-horsepower plant. According to his skill, the fireman is able to save $10 and more of this. His pay generally varies from $1.75 a day up to $2.50 a day. Question: If a well paid fireman is equivalent to one who has the requisite skill, how much is saved by paying a fireman a dollar less a day?

ROLLING TAPERED FORGINGS*

TYPICAL MACHINES AND EXAMPLES OF WORK PRODUCED ON THEM

BY FRANK H. BLAKESLEE†

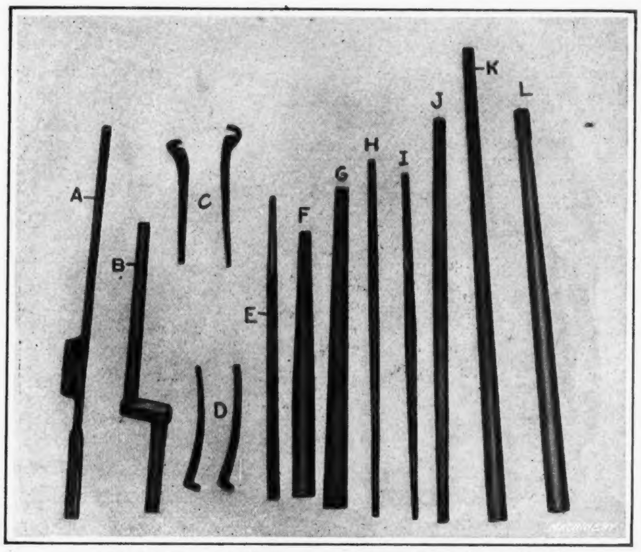


Fig. 1. Typical Examples of Tapered Work produced between Forging Rolls

TAPER forging rolls are advantageously employed for the rapid and economical production of tapered forgings; and typical examples of work which may be produced between taper forging rolls are shown in Fig. 1. Such parts are commonly forged under the hammer, but rolling enables the work to be done in less time and it is claimed that better results can also be produced by this method. The use of forging rolls insures a high degree of uniformity, and in those forgings where the appearance is a matter of importance the rolled work has the further advantage of being entirely free from hammer marks. The taper forging rolls consist essentially of a pair of rolls carried on shafts mounted between heavy housings. The rolls are half cylinders, and the shafts on which they are carried are driven by the usual arrangement of gearing and a flywheel. The rolls are provided with double adjustment, the vertical adjustment being made by raising or lowering the upper shaft bearings in the housings to allow for handling stock of various thicknesses. This adjustment also allows the rolls to be refinished when they become worn. The rolls are held in either a concentric or an eccentric position on their shafts by set-screws; the amount of eccentricity may be adjusted by loosening the set-screws on one side of the shaft and tightening those on the other side. By varying the eccentricity of the rolls different tapers may be produced in any pair of grooves in the rolls.

Fig. 2 shows a typical taper forging rolling machine built by the Ajax Mfg. Co., Cleveland, Ohio. This machine is adapted for either belt or individual motor drive, and is geared down from the flywheel to the rolls so that the latter run at a speed which is convenient for the operator. In making taper forgings on this machine, the stock is pushed through the space between the shafts when the rolls are apart. Then as the rolls come together they catch the work and carry it back toward the operator. It will be seen that the rolls are provided with grooves in which the work runs. At the front of the machine will be seen a cross-bar provided with grooves similar to those in the rolls and in alignment with them. In pushing the work through while the rolls are apart, it is slid along in the groove in the cross-bar corresponding with the grooves in the rolls in which it is desired to forge the work.

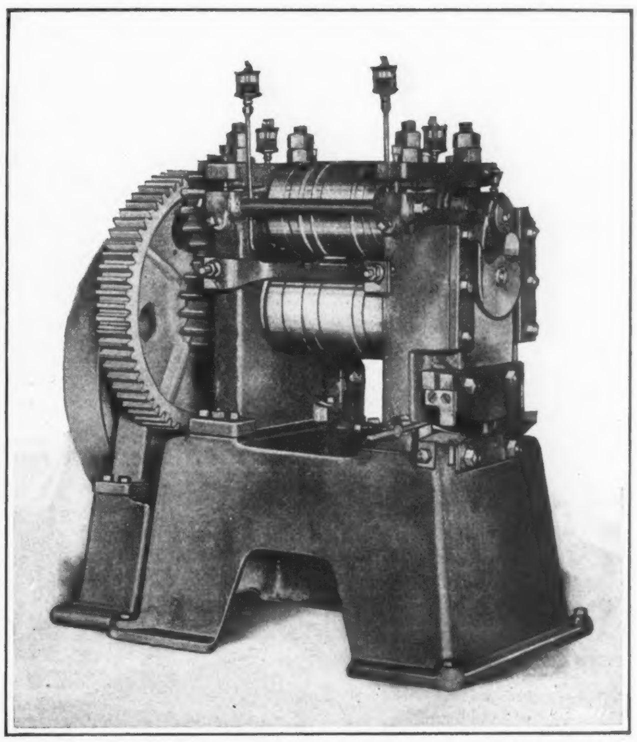


Fig. 3. Special Rolling Machine for forging Tapered Brake Shoe Keys

This provides a rapid though effective method of guiding the work. Where wide, flat stock is to be rolled to a taper on the larger dimension, straightening rolls are provided, between which the work is rolled after each pass through the taper forging rolls, thus providing for keeping the smaller dimensions of the work constant. The standard machines are provided with a shear on the outside of the right-hand housing, which is operated by an eccentric on the upper roll shaft. This shear is found useful in trimming off the rough ends of forgings.

Referring again to the tapered forgings shown in Fig. 1, the piece marked *A* is a Bailey body-loop used in the manufacture of carriages. The center of this piece is drop-forged, leaving square ends which are easily drawn down to the required oval section by passing the work through the forging rolls. About 1400 of these parts can be turned out in a ten-hour day. Piece *B* is a knuckle, the ends of which are rolled to a taper. The taper on both ends of these knuckles may be produced without requiring the rolls to be changed, as each set of rolls is provided with several grooves so that different classes of work may be accommodated. The tong handles shown at *C* are rolled down from stock of the re-

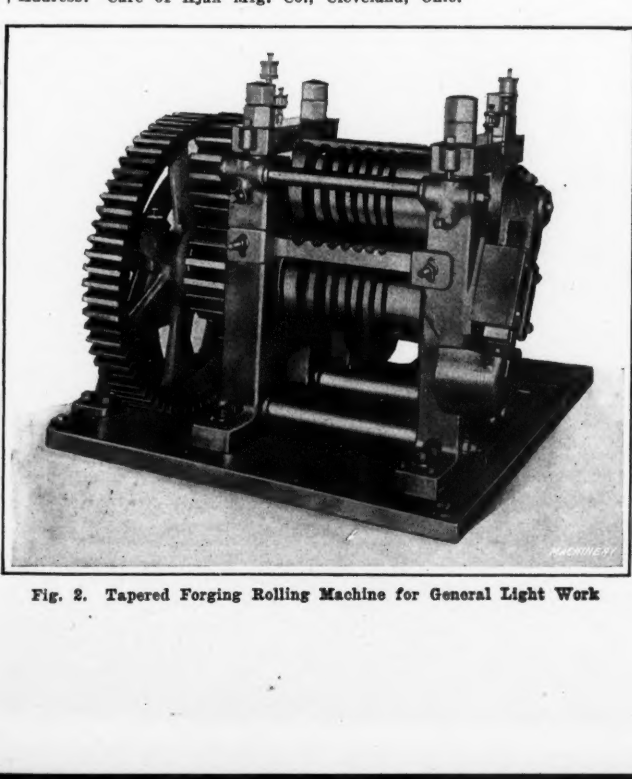


Fig. 2. Tapered Forging Rolling Machine for General Light Work

* For additional information on machine forging published in MACHINERY, see also "Machine Forging Gear Blanks" by D. T. Hamilton, November, 1914; "Cold Heading" by C. L. Lucas and E. W. Duston, published in three installments in May and July, 1913, and February, 1914; "Forging and Machining Automobile Front Axles," December, 1913; and "Machine Forging" by Douglas T. Hamilton, published in six installments in April, May, June, July, September, and October, 1913.

† Address: Care of Ajax Mfg. Co., Cleveland, Ohio.

quired cross-sectional area for forging the heads of the tongs. The pieces shown at *D* are brake shoe keys, which were made on the Ajax special brake-shoe key rolling machine shown in Fig. 3. The bar shown at *E* has a round tapered section rolled on the end, this being a typical form of forging used in the manufacture of various agricultural implements. Various forms of tapered pipes are shown at *F*, *G*, *H*, *I*, *J*, and *K*, the tapers on which were produced between taper forging rolls. Tapered pipes are produced by this method in the same manner as the solid bars, except that it requires more passes between the rolls to produce the same taper because there is a tendency to crush the pipe if it is attempted to obtain too great a reduction at a single pass.

The drag bar shown at *L* is an interesting example of a rolled taper forging because of the enlarged section at the small end of the taper. This forging is made by rolling the bar stock down to the required section at the upper end of the piece, this operation being performed in straight grooved rolls of suitable size. After this operation is completed, the rolled end is gripped with a pair of tongs and rolled from the smaller to the larger section. This method of rolling the taper by making a greater reduction during the first part of the rolling operation is at variance with ordinary practice, but is necessary in this case owing to the enlarged section at the small end of the work. The usual practice of rolling from the larger to the smaller section is adhered to in all cases where such a procedure is possible, because of the ease of handling and consequent efficiency of production. In any rolling operation there must be a reduction of the cross-sectional area; and consequently, the stock used for a rolled forging must have a section equal to or larger than the largest cross-section of the tapered forging which it is desired to produce. Many tapered forgings are tapered toward both ends or have a straight extension at one end of the taper; and such forgings can be economically produced by rolling. A back stop is provided at the back of the machine, against which the work is located as it is pushed through ready to be gripped between the rolls.

The manufacture of the brake shoe keys shown at *D* in Fig. 1 is handled very efficiently on the special brake-shoe key rolling machine shown in Fig. 3. Rectangular stock is used, and by heating the bar for a sufficient distance two keys may be finished before it is necessary to reheat the material. After the taper has been rolled on the end of the bar of stock,

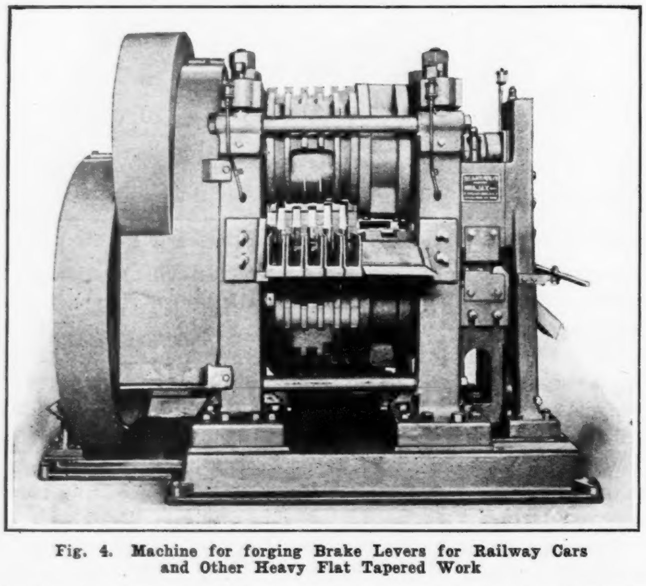


Fig. 4. Machine for forging Brake Levers for Railway Cars and Other Heavy Flat Tapered Work

the key is sheared off, bent, and trimmed by a single stroke of the slide carried on the outside of the right-hand housing. The machine runs at 50 revolutions per minute and it has been found possible to produce 1200 keys in a ten-hour working day.

Another taper forging rolling machine made by the Ajax Mfg. Co. is shown in Fig. 4, the most noteworthy feature of this machine being its unusually large size. This machine is provided with special attachments for use in finishing brake levers for railway cars. Fig. 5 shows a forging which was produced on this machine, and in this connection it may be mentioned that the rolls are large enough to handle taper forging operations on flat stock as large as 10 inches wide by 1½ inch thick. The greatest difficulty encountered in rolling the taper on such large pieces is that their weight makes the handling of the work a difficult matter. This difficulty is minimized on the machine shown in Fig. 4 through the provision of exceptionally long guides in which the grooves are cut deep enough to allow tongs to be used which have a small roller on the under jaw. The material can be brought to the machine by a light traveling crane and rolled between

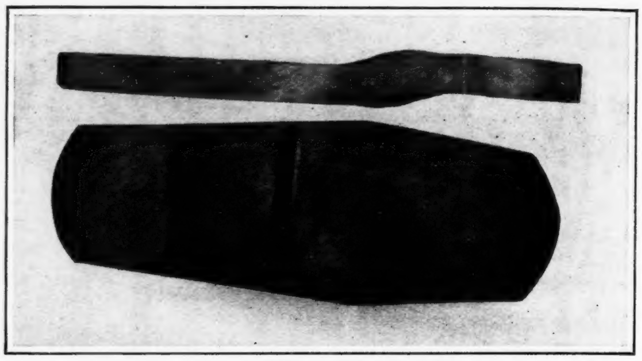


Fig. 5. Example of Tapered Forging rolled on Machine shown in Fig. 4

the rolls on the tongs. Owing to the heavy nature of the work, this machine is designed to run at only 25 revolutions per minute. After the taper has been rolled on each end of the work shown in Fig. 5, the piece is transferred to the shear where the ends are trimmed off. Owing to the exceptional weight of the work, it will be seen that an extra housing is provided on the machine to afford outboard support for the eccentric shaft which operates the shear. The off-set in the work is produced by removing the shear blocks and setting up bending dies in their place. The arrangement of the drive of this machine is similar to that of the machine shown in Fig. 3, the gearing and flywheel being completely covered by heavy iron guards.

* * *

Delegates from about twenty technical, national and scientific societies met in the United Engineering Societies Bldg., 29 West 39th St., New York City, May 21, to perfect a permanent organization for the purpose of preparing a classification of the literature of applied science which might be generally accepted by these and other organizations. The idea was expressed that the publishers of technical periodicals could be induced to print against each important article, the symbol of the appropriate class in this system, so that by clipping these articles, a file might be easily made which would combine in one system these clippings together with trade catalogues, maps, drawings, blueprints, photographs, pamphlets and letters classified by the same system. W. P. Cutter, librarian of the Engineering Societies library, read a paper "The Classification of Applied Science," in which he outlined a plan whereby the central office could collate all existing classifications, and with the help of specialists in the various national societies interested, might compile a general system which would meet with general acceptance and adoption. A permanent organization was effected by the election of officers: Chairman, Fred R. Low; secretary, W. P. Cutter. The name adopted for the organization is "Joint Committee on Classification of Technical Literature," and the temporary address of the secretary, W. P. Cutter, is 29 West 39th St., New York City.

* * *

The sixteen-inch gun built at the Watervliet Arsenal about ten years ago has been taken to the Panama Canal for coast defense. This is the only sixteen-inch gun built by the United States. The remaining defenses at Panama will consist of fourteen-inch guns. These guns cost approximately $45,000 each and their carriages $85,000 each. The cost of a powder charge is approximately $175, and the cost of an armor-piercing projectile about $500. The cost of the powder charge of the sixteen-inch gun is about $250 and the cost of its armor-piercing projectile about $800.

INTERLOCKING MILLING CUTTERS*

BY CORRESPONDENT

The extent to which interlocking milling cutters have come into use of late years is remarkable. The chief cause for this is undoubtedly a closer study by the users of milling cutters of the advantages derived from the use of interlocking types; another cause is to be found in the more and more universal use of high-speed steel in milling cutters, which, owing to the extra cost over cutters made of carbon steel, makes it imperative that the cutters last longer than formerly.

Cutters are generally made interlocking for three reasons: (1) For the maintaining of a certain width. (2) To be able to mill two or more distinct widths with the same set of cutters. (3) To be able to make cutters of unusually long dimensions in sections, and at the same time insure as good results in milling as with a solid cutter.

The first reason—probably the most frequent one—is very simple of explanation. Cutters in use naturally wear and become dull, etc., and hence have to be sharpened, and from this operation they naturally become under size as far as width is concerned. A solid cutter would become under size after the first sharpening, and hence useless, and a new cutter would have to be procured; an interlocking cutter, on the other hand, can be used after several grindings, or practically until worn out. The second reason is similar to the first and, of course, gives the same advantages, except that when the cutters are set for the largest width of cut, the extent to which the cutters can be sharpened may be somewhat limited, depending upon the depth of the interlock in relation to the largest width. Using an interlocking cutter in this case makes a saving of one solid cutter plus the advantages set forth in reason No. 1. Cutters of long dimensions are generally made in sections. If made, however, as shown in Fig. 1, the result in the work being milled will after a very short time be a ridge in the flat surface, as the extreme corners of the cutters, even if in absolute line with each other, become rounded; this trouble is avoided by making the sections interlocking. The corners of the cutters when they become rounded have no effect upon the work being milled, if so made. Other reasons for making cutters of extreme length dimensions interlocking or in sections, are naturally the greater ease with which they can be made, and the elimination of risk in the hardening operation.

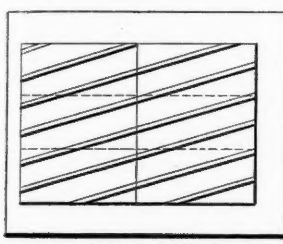


Fig. 1. Milling Cutter in Two Sections, not interlocked

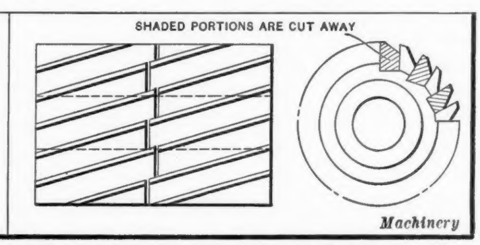


Fig. 2. Cutter in Fig. 1 interlocked to prevent Formation of Ridge in Flat Surface being milled

Most cutters, as before mentioned, are made interlocking in order to be able to maintain a certain width; this makes it quite necessary that the two or more interlocking sections run true, so that the cutter will cut a slot to the exact width of the assembled cutter. In order to insure the trueness of the sections, it is advisable to make the hubs or resting surfaces between the sections as large as possible. Figs. 2 and 3 show such interlocking cutters which are not only easy to make, but which make the maintenance of the trueness of the cutter when expanding them or contracting them a simple operation. For the expanding of these cutters as well as the one shown in Fig. 4, thin paper or metal washers, true in thickness, are used.

* For information on this subject previously published in MACHINERY see "Milling Cutters," April, 1906.

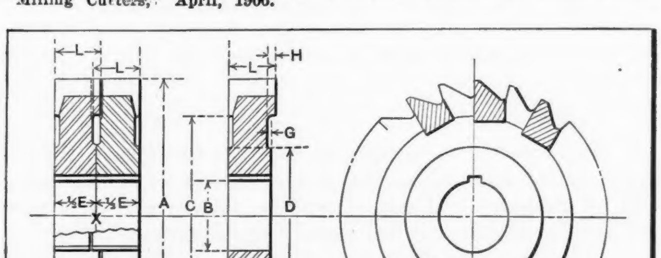


Fig. 3. Interlocked Side Milling Cutter

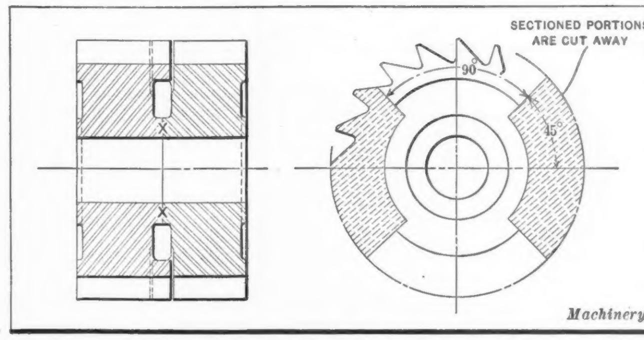


Fig. 4. Another Method of Interlocking Milling Cutters

It can be readily seen that while the interlock as shown in Fig. 5 looks very simple, it is, in fact, a most expensive one to make accurately, and it by no means insures accuracy when expanding as do the other interlocks shown; in this case, pieces of paper or sheet metal inserted between surfaces X are used when expanding. It is comparatively easy to grind the surfaces on section Y true with the hole, this being done on an arbor, but when one tries to grind the surfaces on section Z true with the hole, the problem is quite difficult and expensive. If these surfaces as well as those in Figs. 2, 3, and 4 do not run true, the result will be an untrue cutter, bent arbor, etc., as any mechanic knows.

The depth of the interlock varies according to the purpose for which the cutters are made interlocking. If made interlocking for the purpose of maintaining a certain width, the depth need only be large enough to allow for several grindings or sharpenings, or until the outside teeth have been ground away to make the cutters practically useless. If cutters are made interlocking in order to obtain two or more distinct widths, the depth of the interlock is, of course, controlled by the difference between the widths desired. This difference should in ordinary cases, however, not be over 1/4 to 3/8 inch, as the higher the projecting sections of the members of the cutter are, the weaker they will become. On interlocking cutters of large dimensions or of heavy construction, these dimensions can naturally be increased; on the other hand, on thin cutters they will have to be materially decreased. Cutters of large dimensions as to length, and for this reason interlocked, need have the recesses or depth of the interlock only deep enough to prevent ridges from forming when milling.

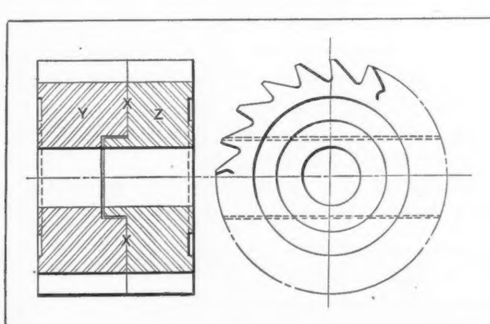


Fig. 5. Interlocking Method in which True Surfaces are Difficult to obtain

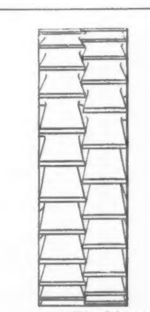


Fig. 6 Simple "Interlocked" Cutter

Of the various interlocks shown, the one shown in Figs. 2 and 3 is undoubtedly the most universally used, owing to its simplicity and consequent cheapness; one finds this style

DIMENSIONS OF INTERLOCKED MILLING CUTTERS

(See Fig. 3 for Notation)

A	B	C	D	Width and Depth of Square Keyway	Number of Teeth
2	5/8	1 1/2	1 1/16	1/8 x 1/16	20
2 1/4	5/8	1 21/32	1 1/8	1/8 x 1/16	20
2 1/2	3/4	1 15/16	1 5/16	1/8 x 1/16	22
2 3/4	3/4	2 1/16	1 3/8	1/8 x 1/16	22
3	1	2 1/4	1 5/8	5/32 x 5/64	22
3 1/4	1	2 3/8	1 3/4	5/32 x 5/64	22
3 1/2	1	2 5/8	1 3/4	5/32 x 5/64	24
3 3/4	1	2 7/8	1 7/8	5/32 x 5/64	24
4	1 1/4	3	2	3/16 x 3/32	24
4 1/2	1 1/4	3 5/16	2 1/4	3/16 x 3/32	24
5	1 1/4	3 11/16	2 1/4	3/16 x 3/32	26
5 1/2	1 1/4	4	2 3/8	3/16 x 3/32	26
6	1 1/4	4 3/8	2 5/8	3/16 x 3/32	28
6 1/2	1 1/4	4 1/2	2 5/8	3/16 x 3/32	28
7	1 1/2	5 1/16	2 3/4	1/4 x 1/8	28
7 1/2	1 1/2	5 9/16	3	1/4 x 1/8	28
8	1 1/2	6 1/8	3 1/4	1/4 x 1/8	28
8 1/2	1 1/2	6 1/2	3 5/8	1/4 x 1/8	30
9	1 1/2	7	3 3/4	1/4 x 1/8	30
9 1/2	1 1/2	7 3/8	3 7/8	1/4 x 1/8	30
10	1 1/2	7 7/8	4	1/4 x 1/8	30
10 1/2	1 1/2	8 1/4	4 1/8	1/4 x 1/8	32
11	1 1/2	8 3/4	4 1/4	1/4 x 1/8	32
11 1/2	1 1/2	9	4 3/8	1/4 x 1/8	32
12	1 1/2	9 5/8	4 1/2	1/4 x 1/8	32

Machinery

of interlock on the cutters most often made interlocking—straddle milling cutters or side mills. The accompanying tables give practical dimensions for these cutters, and the faults generally found with these cutters as supplied for the market—too small hubs and lack of system for the dimensions of the recess in relation to different diameter holes—have been remedied.

In Fig. 6 is shown an interlocking cutter which anyone can procure at small expense. It consists of two ordinary side mills placed side by side with their hubs ground down so that the teeth of one of the cutters interlock into the spaces or between the teeth of the other. In this kind of interlocking cutter it is natural that the depth of the interlock cannot be very great, this depending upon the depth of the side teeth and the shape of the teeth.

* * *

Since the European war began, states the *Iron-monger*, people interested in the German silver trade in Great Britain have ceased to describe this product as German silver and have substituted for it the term nickel-silver. The term German silver dates back to 1830, when Herr Guitike, from Berlin, brought to Sheffield the first sample of this metal. The alloy came originally from China where its composition is said to have been known from time immemorial.

DIMENSIONS OF INTERLOCKED MILLING CUTTERS

(See Fig. 3 for Notation)

E	F	G	H	K	L
3/8	1/32	1/32	1/16	1/64	7/32
7/16	1/32	1/32	1/16	1/64	1/4
1/2	1/32	1/32	1/16	1/64	9/32
9/16	3/64	1/32	1/16	1/64	5/16
5/8	3/64	3/64	3/32	1/64	23/64
11/16	3/64	3/64	3/32	1/64	25/64
3/4	1/16	3/64	3/32	1/64	27/64
13/16	1/16	3/64	3/32	1/64	29/64
7/8	1/16	3/64	3/32	1/64	31/64
15/16	1/16	3/64	3/32	1/64	33/64
1	1/16	3/64	3/32	1/64	35/64
1 1/8	5/64	1/16	1/8	1/64	5/8
1 1/4	5/64	1/16	1/8	1/64	11/16
1 3/8	5/64	1/16	1/8	1/64	3/4
1 1/2	5/64	1/16	1/8	1/64	13/16
1 5/8	5/64	3/32	3/16	1/64	29/32
1 3/4	3/32	3/32	3/16	1/64	31/32
1 7/8	3/32	3/32	3/16	1/64	1 1/32
2	3/32	3/32	3/16	1/64	1 3/32
2 1/4	3/32	1/8	1/4	1/64	1 1/4
2 1/2	3/32	1/8	1/4	1/64	1 3/8
2 3/4	3/32	1/8	1/4	1/64	1 1/2
3	3/32	1/8	1/4	1/64	1 5/8

Machinery

INSTRUMENT FOR SOLVING SPIRAL GEAR PROBLEMS*

METHOD OF DETERMINING THE REQUIRED HELIX ANGLES OF THE GEAR AND PINION

BY GEORGE M. BARTLETT†

The determination of the tooth angles of spiral gears, where the distance between the shafts is unalterable, is usually a troublesome problem, no royal road having yet been found to the exact solution, except by the "cut-and-try" method which is not very well understood. It is the purpose of this article to describe, first, a graphical solution of the problem, which depends for its correctness only upon the accuracy of the diagram as laid out; and second, an instrument based on this graphical method which, if accurately made, will give the required spiral angles with a sufficient degree of accuracy for all practical purposes.

Let θ = angle between shafts;

C = center distance;

$$V = \text{ratio}\ \frac{\text{R. P. M. of pinion}}{\text{R. P. M. of gear}};$$

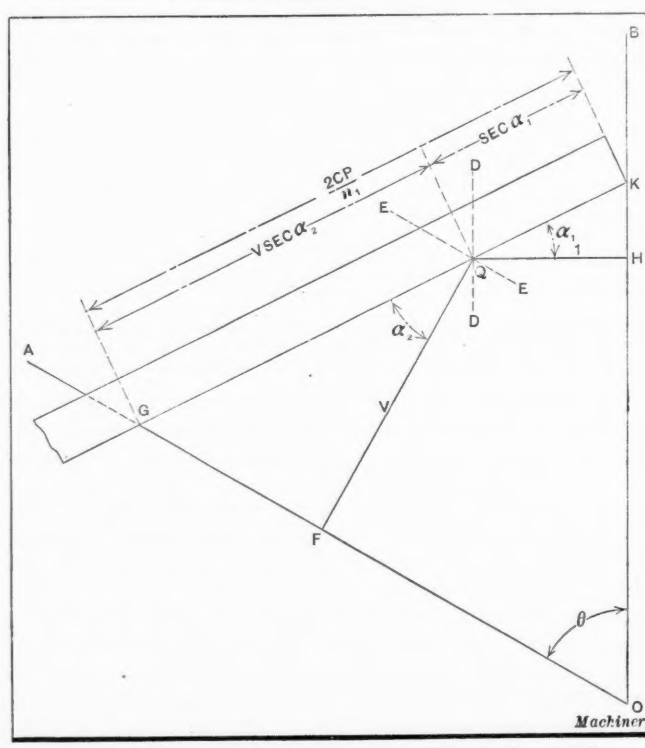


Fig. 1. Graphical Method of determining Helix Angles of Pair of Spiral Gears to fulfill Specified Conditions

P = diametral pitch of cutter;

α_1 = angle between tooth helix and axis of pinion;

α_2 = angle between tooth helix and axis of gear;

N_1 = number of teeth on pinion;

N_2 = number of teeth on gear.

The preliminary procedure is as follows: Given the velocity ratio V, the angle θ between the shafts, and the center distance C; provisional values for the tooth angles α_1 and α_2 are first assumed as nearly equal as possible, and such that $\alpha_1 + \alpha_2 = \theta$. The pitch of the cutter is also assumed.

$$N_1 = \text{the nearest integer to}\ \frac{2\,CP\cos\alpha_1}{1 + V\dfrac{\cos\alpha_1}{\cos\alpha_2}}.$$

$$N_2 = VN_1.$$

If the value for N_1 chances to be an exact integer, the assumed values of α_1 and α_2 will be correct, and no further work will be necessary. If not, it will be necessary to find new values of α_1 and α_2 that will satisfy the equation:

$$\frac{2\,CP}{N_1} = \sec\alpha_1 + V\sec\alpha_2.$$

* For additional information on the subject of spiral gear design published in MACHINERY, see "Tables of Spiral Gears Having a Ratio of 2 to 1," June, 1914; "Formulas for Spiral Gear Combinations," March, 1913; "Spiral Gear Design," December, 1912, and January, 1913; and other articles there referred to.

† Address: 2609 North Delaware St., Indianapolis, Ind.

This may be done by a series of trials, which in time will lead to a very accurate determination of the required angles; but the graphical construction shown in Fig. 1 will give the result more quickly. Draw OA and OB, making the angle between them equal to the angle θ between the shafts. Draw DD parallel to OB and at a distance of unity from it. Draw EE parallel to OA and at a distance of V units from it. These lines intersect at a point Q. From this point drop perpendiculars QF and QH to OA and OB, respectively. Now take a strip of paper with a perfectly straight edge, and lay off upon it a distance GK equal to $\frac{2\,CP}{N_1}$. Place this strip so that its edge touches the point Q, and so that the points G and K lie on the lines OA and OB, respectively. Then the angles KQH and GQF will be equal to the required angles α_1 and α_2, respectively. An inspection of the figure will show this to be correct.

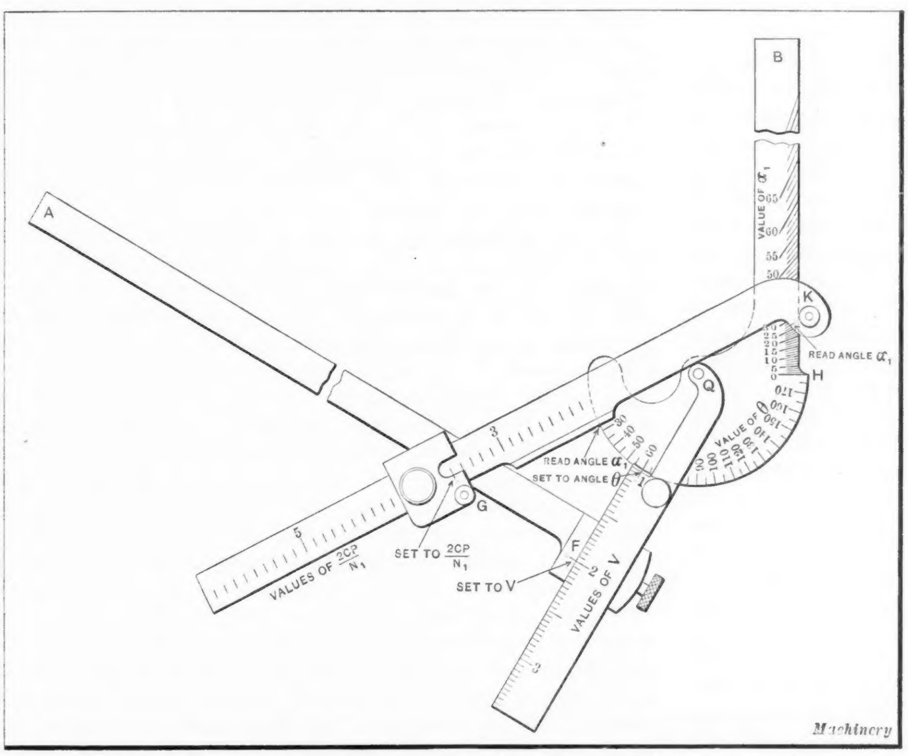


Fig. 2. Instrument for determining Required Helix Angles for Spiral Gears, based on Graphical Method illustrated in Fig. 1

To illustrate the use of this method in determining the proper helix angles for a pair of spiral gears, we will employ it in solving the following problem: Consider a case in which the velocity ratio is 2; the angle θ between the shafts, 60 degrees; the center distance C between the shafts, 7 inches; the diametral pitch of the gear cutter, 6; the helix angle α_1 of the pinion, approximately 30 degrees; and the helix angle α_2 of the gear, approximately 30 degrees. By calculation we find that the number of teeth N_1 on the pinion is:

$$N_1 = \frac{2\,CP\cos\alpha_1}{1 + V\dfrac{\cos\alpha_1}{\cos\alpha_2}} = \frac{2\times 7\times 6\times 0.866}{1 + 2\times\dfrac{0.866}{0.866}} = 24.248.$$

From the preceding calculation we see that the number of teeth N_1 on the pinion is 24 (taking the nearest integer); and $N_2 = N_1 \times V = 24 \times 2 = 48$. We must now proceed to find all values for α_1 and α_2 which will satisfy the following equation:

$$\frac{2\,CP}{N_1} = \sec\alpha_1 + V\sec\alpha_2.$$

Proceeding according to the graphical method of solution illustrated in Fig. 1, we lay off OA and OB, making the angle between them equal to the shaft angle θ or 60 degrees. Next draw the line DD parallel to OB and at a distance of 1 inch from it. Then draw EE parallel to OA and at a distance of 2 inches from it, bearing in mind that the velocity ratio V is 2. By calculation we find that the distance GK which must be laid off on the strip of paper is:

$$\frac{2\,CP}{N_1} = \frac{2\times 7\times 6}{24} = 3.5 \text{ inches.}$$

This strip of paper is then applied to the diagram as previously explained, and the angle KQH or α_1 (Fig. 1) is found to be 27 degrees, 25 minutes. $\alpha_2 = \theta - \alpha_1 = 60$ degrees $- 27$ degrees, 25 minutes $= 32$ degrees, 35 minutes.

Fig. 2 illustrates a direct-reading steel instrument which is designed for use in determining the value of α_1, after which the value of α_2 is found by taking the difference between θ and α_1. In using this instrument it is only necessary to make three settings, *i. e.*, one for the value of the shaft angle θ, one for the value of the velocity ratio V, and one for the fraction $\frac{2\,CP}{N_1}$. After making these settings, the loose blade GK is moved so that the button K at one end is in contact with the vertical blade B, with the middle portion of the loose blade touching the curve at Q, and the button G which is set to correspond with the value of the fraction $\frac{2\,CP}{N_1}$ in contact with the straight edge of the blade AF. After the instrument has been adjusted in this way, the value of the helix α_1 on the pinion is read on the scale B of the instrument. It will be found that there are in general two positions of the loose blade which will fulfill all conditions, and in either of these positions correct determinations may be obtained for the values of the helix angle α_1 on the pinion and the helix angle α_2 on the gear. The best results will be obtained by using the pair of values for these angles which are most nearly equal. It will be evident that the reference letters in Fig. 2 correspond with those of Fig. 1, from which the analogy between the method of solving the problem with the instrument and by the graphical method will be seen.

* * *

The manufacturer who intends to go into the export trade should remember that the three cardinal sins charged against American firms are that they do not always ship exactly what is ordered; that they are liable to substitute goods to suit their own judgment; and that they are not careful as to packing.

* * *

UNEMPLOYMENT IN FIFTEEN CITIES OF THE UNITED STATES

The Bureau of Labor Statistics of the United States Department of Labor is making a series of investigations into unemployment. The second study of this series, which was undertaken for the bureau by the Metropolitan Life Insurance Co., includes the following fifteen cities outside of Greater New York and the Metropolitan district of Northern New Jersey, which territory was covered in the first study of unemployment published in Bulletin 172. The cities are: Boston, Bridgeport, Chicago, Cleveland, Duluth, Kansas City, Milwaukee, Minneapolis, Philadelphia, Pittsburg, St. Louis, Springfield, Mo., St. Paul, Toledo, Wilkesbarre. The cities include 399,881 families, in which there were found 644,358 wage earners. Of this number, 73,800 or 11.5 per cent of all wage earners in the families visited were wholly unemployed and in addition thereto 106,652, or 16.6 per cent were reported as part-time workers. The highest per cent of unemployment was found in Duluth, Minn., where 20.3 per cent of the wage earners were without work, and 17.8 were working part time only. The lowest percentage of unemployment was found in Bridgeport, Conn., where only 4.3 per cent were unemployed, and 19.9 per cent were working only part time. This report was published May 31, 1915.

LUBRICATION OF BALL BEARINGS

BY L. G. LONG*

It is not so very many years ago that we were told that ball bearings required no lubrication, and if kept free from dirt, moisture, etc., were more efficient when run perfectly dry. Experience has proved this to be erroneous, and it is now generally accepted that lubrication is absolutely necessary when high speeds are to be maintained or heavy loads carried. Just why this is so is easily understood if we stop to consider the construction and operation of a ball bearing under load and motion. In order that the balls shall maintain their distributed relation to one another, some sort of spacer or distance piece is inserted between the respective balls. This spacer may be of one piece or it may be made up of several pieces, and various types are to be found in bearings of different makes; but practically all ball bearing manufacturers have adopted some kind of spacer in their annular type of bearings.

Were no spacer used, it is evident that the balls would rub against one another, and it is just as evident that they must rub against the spacer, producing a certain amount of friction which might be very slight, but still less harmful if the rubbing surfaces are lubricated. While the material from which both balls and races are made is very hard, it is to a certain extent elastic, and consequently subject to slight deformation. Theoretically, a ball bearing has purely rolling contact and the path of the balls about the races is a line, but in actual practice, when subjected to a load, each ball is compressed as it comes under the load, and the line path becomes appreciably wider. This constant and rapid compressing and releasing of the balls tends to cause "fatigue" in the metal just the same as under repeated hammer blows; and it also tends to generate heat, which is more readily dissipated in the presence of a lubricant. As each ball passes out of the zone of pressure, it is snapped out much as one snaps a melon seed from between the fingers, ending up with a smart blow against the retainer, the action being repeated very rapidly, and in high-speed bearings this is yet another source of heat.

We must grant that the bearing makers have provided wonderfully in this regard with their special heat-treated steels and scientifically made retainers, so that when a bearing load is kept within rated guarantees, and a good lubricant is used, cool and quiet running bearings result. But instead of the theoretically free rolling frictionless contact, we have some such condition as the following: Each ball in its turn is forced under the load, where it undergoes a deformation due to the load pressure, and as it passes from under the load it is snapped very smartly against the retainer. All of these operations are repeated many times per minute in a ball bearing under load and motion, and can easily become destructive if the bearing is allowed to run dry. Yet all of these pressures, frictions and blows need not cause worry to the bearing user if his bearings are properly mounted, loaded and lubricated, as it is only when the load becomes sufficient to cause permanent deformation to either balls or races that trouble occurs, or when lubrication fails to take care of the heat and friction. The successful operation of ball bearings depends upon proper mounting, safe loads and proper lubrication.

Requirements of a Satisfactory Lubricant

It is not the writer's intention to lay stress on the fact that lubrication is necessary, as this is generally accepted, but only to tell why and to emphasize very strongly that *proper* lubrication is the crying need, and also endeavor to explain what constitutes a proper lubricant. Too many have believed that oil is just oil, and that grease is simply grease; and that what is good enough for the bearing of the wheelbarrow, the tram car or lineshaft is all right for ball bearings, but let us consider the requirements of the ball bearing carefully before we load it up with cheap cup grease. A modern ball bearing is one of the finest examples of workmanship and accuracy in the machinery art; the world is searched for the purest iron from which the steel is made, and the most exact care is taken in handling at each step from the ore to the finishing processes. Expensive and minutely accurate machinery, elaborate processes of refining, the most skilled workman, the most careful inspection and efficient engineering have produced this highly accurate bearing. Does not a part of a machine that requires such extreme accuracy to produce deserve careful attention from the user?

Ball bearing makers have spent thousands upon thousands of dollars in order to be able to produce balls that are accurate with one another within limits of 0.0001 inch; in order to produce ball races that are of uniform and exact hardness throughout and with microscopically perfect surfaces; and in order to assemble these balls and races without clearance between them, so that a quiet running bearing can be obtained. They have done these things to produce the most efficient bearing, but is it reasonable to expect it to remain efficient or to be a bearing at all if it is clogged and fouled with gummy, dirty or impure lubricants? If this bearing is to retain its efficiency and give service year after year, its highly finished surfaces must be kept clean and bright. This precludes the use of any lubricant containing either alkali or acid or any substance which upon becoming rancid will produce acid. In this class fall most of the so-called cup greases, being alkaline from the soap used in their formation. Moisture, dust, dirt and abrasives must also be excluded from the bearing.

The oil or grease that is used as a lubricant should be of such a nature as to offer the least resistance to the free movement of the balls around their path that is consistent with its ability to remain in the bearing enclosure. When the design of a ball bearing mounting will permit the use of a fluid oil and oil can be retained in the enclosure or housing, it is a very desirable lubricant, as it is not so difficult a matter to obtain high-grade lubricating oil, but it is very unusual indeed for a horizontally mounted bearing not to leak along the shaft when thin oil is used. The difficulties met with along this line have led most builders of ball bearing machinery to the use of grease or non-fluid oils, finding also that a greater quantity can be put in the enclosure at a time, thus doing away with the necessity for such frequent attention. Unfortunately for the ball bearing, it is very little understood by the average machine user; and it is also unfortunate that he knows very little about greases and of what they are made. He is more than likely to fill his ball bearings with a grease that has been found satisfactory for other purposes without possessing any knowledge of its fitness for ball bearings.

There are many heavily filled soap stock greases which give excellent results in some bearings that will absolutely destroy a ball bearing in a short time, and the majority of the greases on the market are unsuited for the requirements of ball bearings in one or many ways. Of two hundred different commercial greases examined, less than a half-dozen have been found suited to ball bearing use. This looks as though there is scant chance for the user to obtain a suitable grease, but such is the condition and there is much more poor than good grease in use. The best of our ball bearing makers are anxious that their bearings shall have the best lubricant and will generally advise a brand when asked to do so. The best cannot be expected for the least money, nor does it follow that the most expensive is the best, but it is much more likely to be.

Bearing in mind the accuracy of parts, the extremely fine finished surfaces and the close fits of the balls in a ball bearing, it is clear that we do not want anything in a grease that will act as an obstruction, such as chalk, cork, mica, graphite, etc., which are often of coarse consistency. Neither do we want any acid or alkali that would attack the polished surfaces. The majority of greases are alkaline, due to soap used to thicken them, and as a pure mineral oil cannot be saponified some vegetable or animal fat has to be added to make a soap. These organic fats are very likely to become rancid upon exposure, especially in warm weather, and develop destructive acids. Drying oils, thickeners, emulsions and various fillers are added to give the desired consistency and "body" to the grease; and these in themselves are not lubricants, but remain in the bearing and not only act as

* Address: Gibson Automobile Co., Indianapolis, Ind.

obstructions but give a false impression as to the amount of lubricant in the bearing. What we must have is as nearly a pure mineral oil as possible, which is of a consistency that will remain in the bearing at any temperature likely to be encountered. Were it not for the low melting point of petrolatum or vaseline, it would be the ideal lubricant.

Method of Testing Lubricants

While it is necessary that the lubricant for ball bearings or roller bearings be properly prepared for the purpose, the retention of this lubricant is just as essential, and the same is true of the necessity for the exclusion of moisture or dirt from the bearings. To make a bearing housing oil, moisture and dirt tight, and still maintain a filling port, which is necessary where a fluid oil is used, is a very difficult piece of work and not often accomplished in practice. The grease-packed bearing for horizontal construction is generally preferred, as such close fits are not required and much less attention is required in service. The selection of the grease is a more difficult matter than the selection of an oil, and it is safe to say that any good engine oil is suitable for ball bearings, taking into account the load and speed. In general, heavily loaded bearings require a heavier oil than the high-speed lighter loaded ones. The specifications for a good ball bearing grease would be as follows: A pure mineral oil, free from acid, alkali or filler, which contains no substance that will act as an obstruction to the free movement of the balls or that will become rancid with age; and which is of such a consistency that it will be easily retained in the housing; the grease should not melt below 250 degrees F. In order to determine if we have such a product, a few simple tests can be made upon a sample of the grease.

Select a sample which will be an average of the package and examine it first for the presence of acids or alkalies as follows: Shake into a test tube half filled with warm distilled water about a thimbleful of the clean grease, and stir until it is well washed into the water. Test the water with both red and blue litmus paper (which may be obtained at most drug stores) when a change of color of the paper from red to blue or *vice versa* will indicate the presence of either alkali or acid, according to which paper is affected. A few drops of phenol-phthalein indicator dropped into a test tube of greasy water will show pink in the presence of alkali.

Next we would test for the presence of fillers or organic fats. Fill the test tube half full of 86-degree specific gravity gasoline or petrolic ether; stir into this a thimbleful of the grease and continue stirring until the grease is fully dissolved. Then pour into the tube a teaspoonful of 10 per cent solution of phosphoric acid in alcohol and shake vigorously for about three seconds. If the grease contains no filler or organic fats, the solution will remain unchanged in appearance and the phosphoric acid and alcohol will settle to the bottom of the tube; however, should there be a precipitate or a coating on the tube walls, it indicates the presence of an undesirable substance. The nature of this precipitate and the quantity could be determined, but for our purpose it is sufficient to determine its presence only. A grease is generally a saponified oil, and as mineral oil is not saponifiable, a vegetable or animal fat is used to make a soap and part of this mixed with mineral oil acts as a thickener.

The melting point may be determined by heating a quantity of the grease in a vessel and noting the point on a stirring-rod thermometer where the grease becomes fluid and again where it changes from an oil to a grease in cooling down. All tests should be conducted with cleanliness, and a checking test should be made at the same time on a sample of commercial vaseline. Also a test carried through on a sample of known adulteration will act as a further check on the accuracy of the result. The usual condition of adulteration will be found as organic fats, as tallow, wax, resin-oil, wool-grease, horse-oil and some seed- and fish-oils; the fillers are talc, mica, rubber, and sometimes cork or fine sawdust. A pure mineral grease is expensive to make, while cup greases are very cheap but look and feel as good. Don't judge by appearances or the feel of greasiness to the fingers, or by your experience in lubricating plain cylindrical bearings; use the tests, and if still in doubt get the opinion of a chemist.

Ball bearings are forging rapidly to the front in machine practice and making headway in spite of the poor attention they frequently receive. Faulty lubrication can be traced as the cause, either directly or indirectly, of the largest per cent of failures. Ball bearings have been put to use in places where plain cylindrical bearings were formerly used, given about the same kind of lubrication but much less attention, and then they have been condemned when they failed. This is unfair, as the construction of ball bearings is so different from any plain type of bearing that their lubrication needs cannot be judged from the same standards.

* * *

AUTOMATIC INDEXING MULTIPLE DRAWING DIE*

BY JOSEPH M. STABEL†

The upper and lower members of a multiple drawing die for performing six drawing operations at one stroke of the press are shown in Figs. 1 and 2. The lower member, Fig. 1, contains the punches and is equipped with an automatic indexing mechanism which serves to carry the work around so that it is acted upon by the six punches and dies which successively reduce the size of the drawn part. Inasmuch as all of the punches and dies operate simultaneously, evidently a drawn piece is produced at each stroke of the press. Eight operations are required to complete the drawn part and their successive order is indicated by Figs. 3 and 4. The first operation is done in a compound blanking and drawing die equipped with a roll feed; the six operations following are

* For additional information on dies, see the following articles previously published in MACHINERY: "Deep Drawing in Combination Dies," April, 1915; "Dies for Drawing Flanged Shells," March, 1915; "Press Tools for Making a Roller Bearing Cage," March, 1915; "Formulas for Blank Diameters of Drawn Shells," January, 1915; "Edge Radius of Drawing Dies," October, 1914; "Sub-press Dies for Armature Manufacture," July, 1914; "One-piece Armature Disk Tools," March and January, 1914.

† Address: 1653 Main St., Rochester, N. Y.

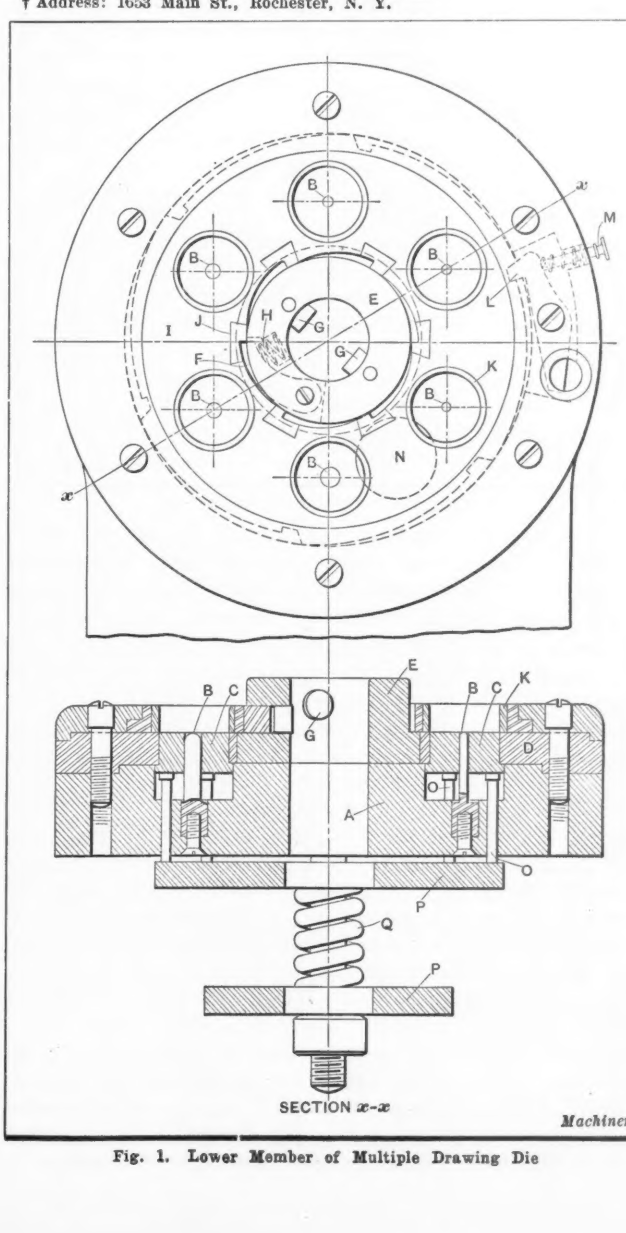


Fig. 1. Lower Member of Multiple Drawing Die

performed in the automatic indexing die, which is the subject of this article, and the eighth or final operation, which consists of turning down a flange and leveling the bottom, is done in another separate die.

The automatic indexing die has a shoe *A* which rests on the bolster of the press and serves to hold six equally-spaced drawing punches *B* and their respective stripping collars *C*. These stripping collars are held in place by retaining ring *D* which also provides a bearing for pawl carrier *E*. This carrier is hardened and ground and has attached to it a pawl *F* (see plan view) and also two hardened pins *G* which engage spiral grooves formed in extension *W* of the upper member (see Fig. 2). The pawl *F* is normally held outward by spring

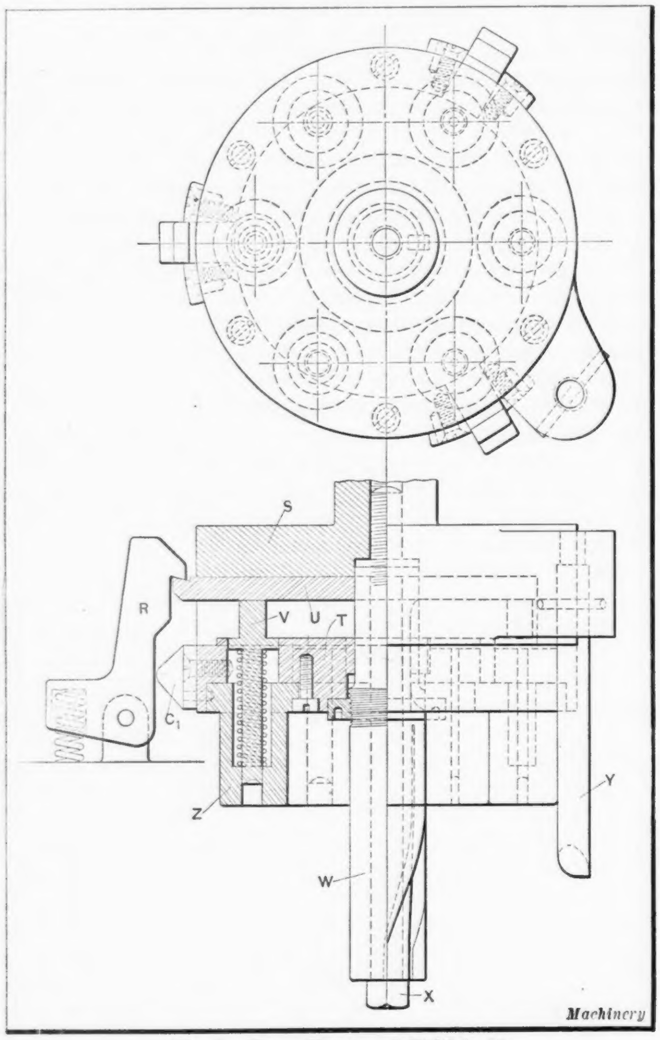


Fig. 2. Upper Member of Multiple Die

H and engages hardened teeth *J* inserted in plate *I*. These teeth take the end thrust of pawl *F* as the latter with carrier *E* is revolved when the press ram ascends. Plate *I*, which is the index plate, has six holes into which are pressed the hardened bushings *K*. On the periphery of this plate there are six slots, engaged by the end of locating lever *L* which serves to hold the plate firmly in position and locate the work accurately relative to the drawing dies. The thumb-nut *M* connecting with lever *L* is used for disengaging the lever when it is desired to turn the index plate by hand, in case it is necessary to remove the drawn parts.

During one revolution of plate *I* each of the six holes passes over the clearance hole *N* which is just beyond the final drawing die, thus allowing the drawn part to drop out of the die and into a box beneath the press. The stripping collars *C* for the punches are actuated by three springs *Q* that are located on a circle underneath plate *P* and are held in position by three studs. These springs normally hold plate *P* upward and also collars *C*, by means of pins *O*.

The steel plate *T* (Fig. 2) is held to punch-holder *S* by screws and serves as the holder for the six drawing dies *Z*. Between holder *S* and plate *T* a space is cored out to receive stripper plate *U* which rests upon the strippers *V*. (The action of this plate will be referred to later.) The driver *W*

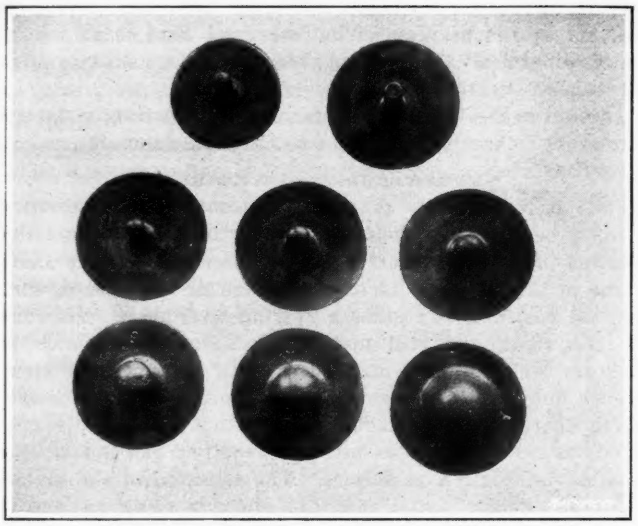


Fig. 3. Successive Operations—Six of which are done in Multiple Die of Automatic Indexing Type

has two spiral grooves milled in it which engage pins *G* (see Fig. 1) and operate the pawl carrier as previously mentioned. The bolt *X* provides adjustment for this driver. The hardened rod *Y* serves to release the locating lever *L* on the lower member so that index plate *I* may be revolved.

The operation of the dies is as follows: When the upper member descends, the successive drawing operations on the six parts are performed (assuming that the die is completely loaded) and at the same time plate *E* and index pawl *F* are turned backward into engagement with the next tooth *J* on plate *I* preparatory to indexing. The rod *Y* also engages the end of locating lever *L* and withdraws it from the index plate. When the upper member ascends the drawn parts are stripped from the punches and dies and plate *E*, with index pawl *F*, is turned forward, thus indexing the six drawn pieces from one die to the next by the rotation of index plate *I*. When lever *L* is released by the upward movement of rod *Y* it drops into a notch and accurately locates and locks the index plate in position. This cycle of movements is repeated for each stroke of the press.

In designing this die, one of the points which had to be considered very carefully was to secure a rapid and positive stripping action for the dies in the upper members; in fact, the drawn parts have to be stripped from the dies as soon as the press slide starts upward so that the work will not be disarranged by being carried up out of the index plate. This positive stripping action was effected by means of plate *U* in conjunction with three levers or pawls *R*. These levers are pivoted to the lower member and as the upper member descends they are forced outward by three cams C_1. At the end of the downward movement, levers *R* are in engagement with plate *U*, as the illustration Fig. 2 indicates. When the slide begins to ascend, plate *U* and the strippers *V* are held stationary while the dies *Z* move upward, thus ejecting the drawn parts. When the cam surface on lever *R* is engaged by cam C_1, it is forced outward, thus releasing plate *U*. In this way the strippers are actuated at the beginning of the upward stroke so that the drawn parts are pushed from the dies without leaving the index plate. As the slide continues to ascend the index plate is revolved into position for the next drawing operation.

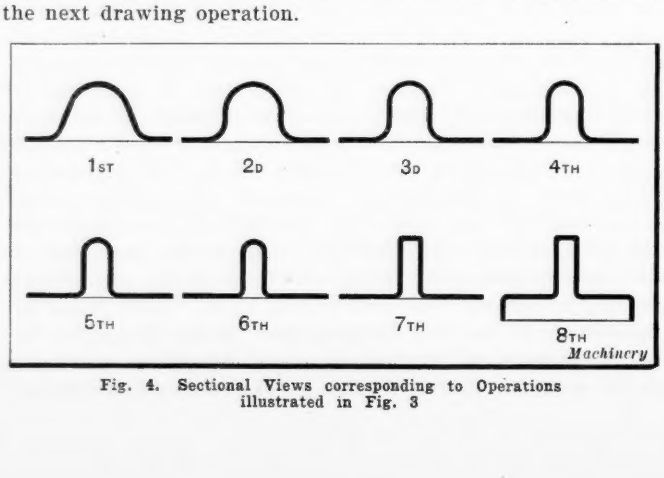


Fig. 4. Sectional Views corresponding to Operations illustrated in Fig. 3

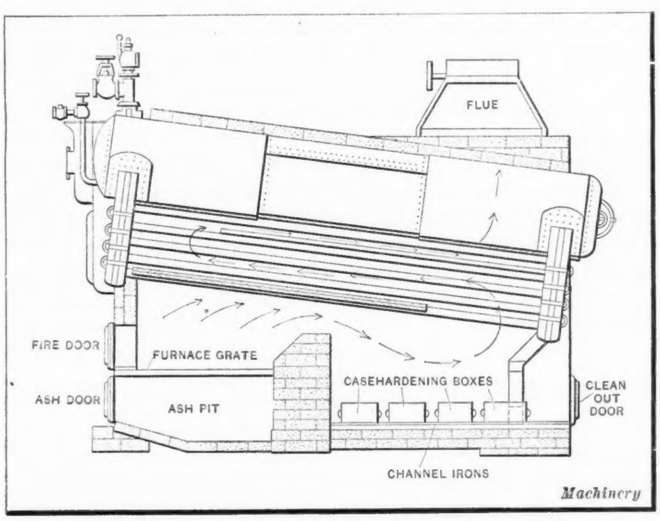
LETTERS ON PRACTICAL SUBJECTS

We pay only for articles published exclusively in MACHINERY

CASEHARDENING IN THE COMBUSTION CHAMBER

We recently started the manufacture of a new line of work which required several parts to be casehardened. We tried hardening a few sample pieces by the cyanide process, but found it too slow and expensive. We were considering the installation of a hardening furnace, but while thinking over the relative merits of installing a furnace or sending the work out to be hardened, the writer hit upon the scheme of conducting the casehardening operation in the combustion chamber of the furnace of one of the steam boilers. We packed the work in a mixture of ground bone and charcoal and placed the boxes in the combustion chamber.

We allowed the work to heat for about 18 hours, after which the casehardening boxes were removed, and at this point we had some trouble. It was necessary to allow the fire to go down in order to remove the boxes, and in this way the work was also cooled to such an extent that it had to be re-heated before quenching. To overcome this difficulty, we constructed a frame from 8-inch channel irons level with the "clean out" door through which the pots were put in the furnace. Handles were placed on the sides of the pots so that a hook



Casehardening Boxes set in Combustion Chamber of Boiler

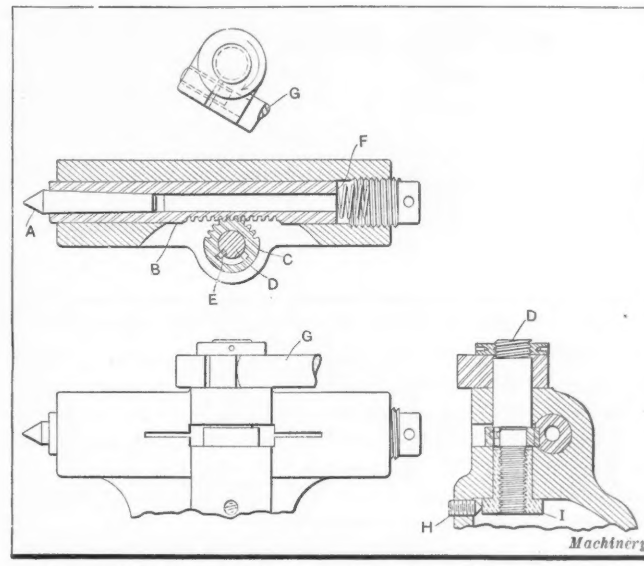
could be used to pull them out of the furnace by sliding them along the channel iron frame. This did away with the necessity of letting the fire go down and since adopting this expedient, we have found the method entirely satisfactory.

Newark, N. J. GEORGE WERNER, JR.

QUICK-ACTING LATHE TAILSTOCK

The accompanying illustration shows an improved form of tailstock for use on lathes and other machine tools where a number of pieces of standard length are to be held between centers. With the ordinary tailstock, two operations are necessary—one to adjust the center and the other to clamp it in place. With the present design, one movement of a lever accomplishes both operations. The center *A* is carried in a sleeve *B* on which gear teeth are cut to mesh with the pinion *C* which moves the center. The stud *D*, which actuates the pinion *C*, has a small pin *E* forced into it. This pin is allowed to move in a slot in the pinion. When the tailstock is released, the spring *F* forces the center forward into contact with the work.

The operation of this tailstock is as follows: The tailstock is set so that the spring *F* will bring the center *A* into contact with the work. In order to release the work from the centers, the lever *G* is moved in the direction indicated by the arrow to draw the center *A* back against the resistance of the spring *F*. The next piece of work is then put in place

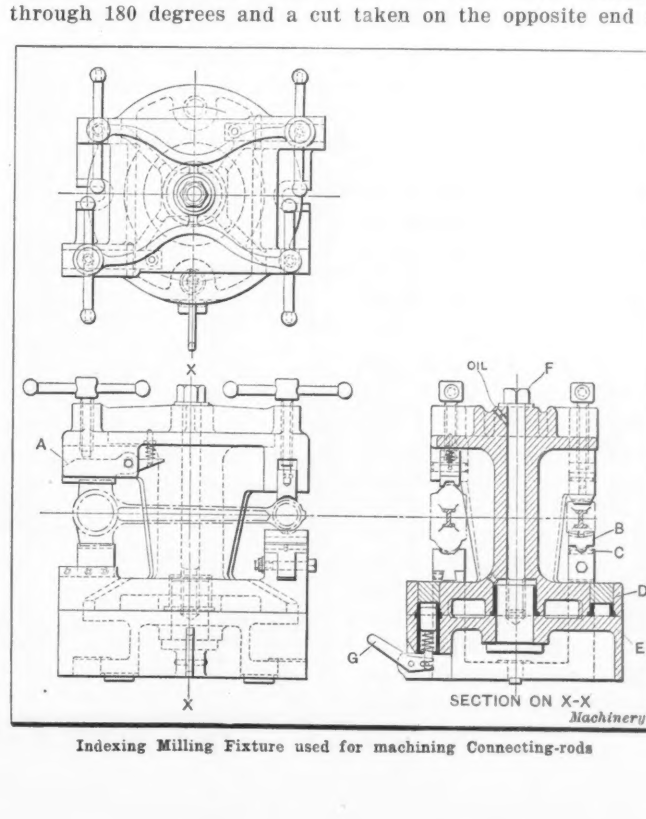


Improved Lathe Tailstock for Rapid Handling of Duplicate Parts

and the lever *G* released; the spring *F* will now return the center *A* into contact with the work. To clamp the tailstock, the lever *G* is moved in the opposite direction to that indicated by the arrow. During this movement, the pin *E* moves in the slot in the pinion *C*, thus allowing the lever *G* to move a certain distance without actuating the pinion *C*. The tailstock casting is split, and this movement of the lever *G* turns the binding screw at the bottom of the stud *D*, thus binding the sleeve *B* and center *A* in place. The screw *H* enters one of a series of slots in the head of the binding nut *I* to prevent it from turning. M. C. T.

CONNECTING-ROD MILLING FIXTURE

The accompanying illustration shows a fixture used for straddle-milling connecting-rods which has been in use by one of the leading automobile manufacturers of Detroit for the past two years. Reference to the illustration will make it clear that two connecting-rods are carried in the fixture at the same time. The ends of the rods are reversed, and after the cut has been taken on one end the fixture is indexed through 180 degrees and a cut taken on the opposite end of



Indexing Milling Fixture used for machining Connecting-rods

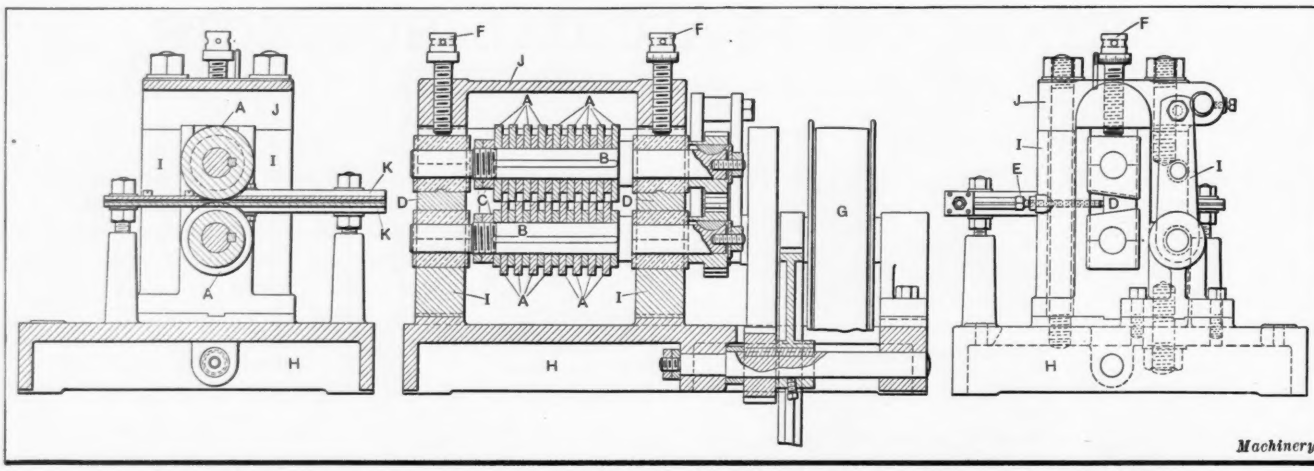


Fig. 1. Machine for cutting up Sheet Stock 6 Inches Wide by 0.012 Inch Thick into Ribbon Stock 0.39 Inch Wide

the rods. Two fixtures are used, one on each end of a No. 3 Cincinnati milling machine, and while the cut is being taken on the work held in one fixture, the other fixture is either being loaded or indexed ready for the succeeding operation. The provision of interchangeable V-blocks for holding the work enables the same fixture to be employed for milling three different sizes of connecting-rods.

In order to be sure of obtaining a firm grip on the work, the upper V-blocks which engage the large ends of the connecting-rods are provided with elongated holes, through which they are pivoted to the fixture, the idea being clearly shown at *A*. It is obviously necessary to prevent twisting the connecting-rods while clamping them in the fixture, as otherwise an inaccuracy would result after the work had been machined and the clamps released. For this purpose, the V-blocks which fit under the small end of each rod have a rocking motion which allows the rods to seat themselves in such a way that there will be no tendency to twist the work. This construction is clearly shown at *B*. The pins *C* under these V-blocks simply serve to prevent endwise motion. In operating the fixture, the body *D* swivels on the base *E* and is clamped by means of the bolt *F*. There should be a clearance of 1/64 inch between the body *D* and base *E* so that the bearing will come on the rim of the base when the bolt *F* is tightened. It will be evident from the illustration that the indexing is done by means of the small lever *G* which withdraws the locating plunger to allow the fixture to be swiveled through an angle of 180 degrees, as previously mentioned.

Detroit, Mich. K. W. Clarke

RIBBON STOCK CUTTING MACHINE

The machine illustrated in Fig. 1 was designed for the purpose of cutting up sheet metal stock 6 inches wide by 0.012 inch in thickness into ribbons 0.39 inch in width. The machine consists of two sets of steel cutters *A* which are keyed to the shafts *B*. These shafts run in bronze bushings and the cutters are locked longitudinally on the shafts by means of the nuts *C*. Means are provided for adjusting the vertical position of the shafts by wedges *D* which are actuated by the horizontal and vertical screws *E* and *F*. The machine is driven by a belt running over the pulley *G*, from which the power is transmitted to the cutter shafts through a train of gearing which rotates the shafts in opposite directions. The entire mechanism is supported on a base *H* and pedestals *I*, these pedestals being separate from the base to facilitate assembling. A cap *J* is securely bolted to the top of the pedestals.

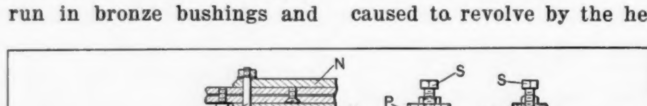


Fig. 2. Mechanism for guiding Stock into Machine

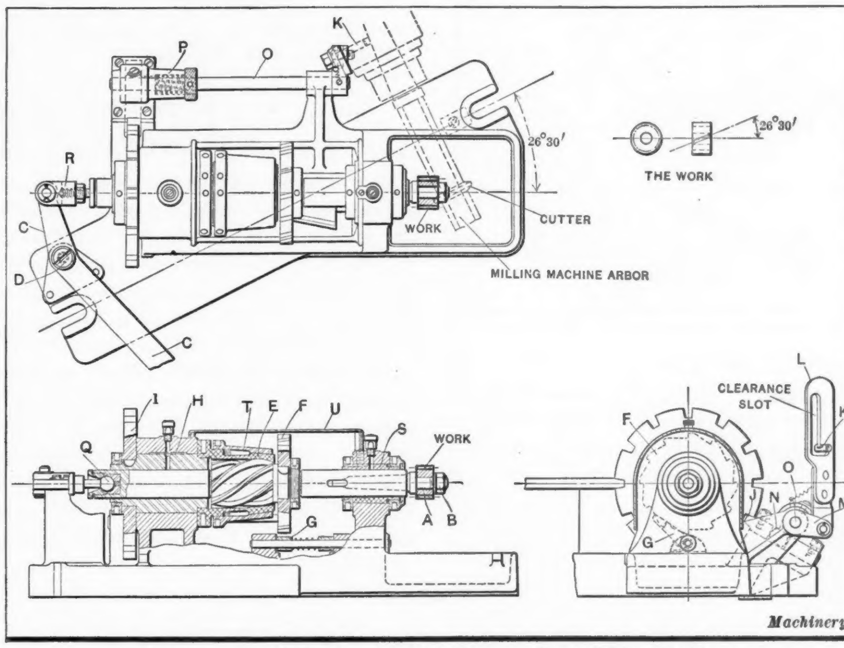
The mechanism for guiding the stock into the cutters and stripping it after the slitting operation has been performed is shown in Fig. 2. It will be seen that this consists of two plates *K*, held a suitable distance apart by means of liners *L* that run the entire length of the stripper. The plates *K* have openings machined in them to receive the cutters *A*. The guiding mechanism is mounted on the threaded studs *M* which are screwed into pillars cast integral with the base *H*. There are two plates *N* on the right-hand side of the guiding mechanism which are movable about a bolt *O* and fastened securely together by a tie-plate *P*. These two plates *N* carry two hardened steel rolls *Q* between them. After loosening the nut *R* which locks the plates in any desired position, they may be adjusted either in or out by regulating the set-screw *S*. A third roll *T* is mounted on the left-hand side of the guiding mechanism and pressed inward by means of a flat spring *U*. The sheet stock is fed between the plates *K* and advanced until the rolls secure a good grip on it, then by adjusting the position of the plates *N* and consequently of the rolls *Q*, the stock is caused to travel through the machine and comes out at the back split into ribbons of uniform width. Johnson Barre

FIXTURE FOR MILLING SPIRAL GEARS

The following describes a fixture for the rapid cutting of spiral gears on a hand milling machine, which possesses the advantage of enabling this work to be done on an inexpensive machine and handled by an unskilled operator. The fixture has given very satisfactory results where small spiral gears are manufactured in large quantities. The table of the hand milling machine on which it is used is locked in position, and the work is held on the arbor *A* by means of nut *B;* and it is fed under the cutter by swinging the lever *C*, which is pivoted at *D*. As the work moves forward, it is caused to revolve by the heavy thread which is machined on the center of the arbor. This thread has the same lead as the teeth of the spiral gears which are to be cut; as a result the gear blank is rotated under the cutter to produce the required form of teeth. Reference to the illustration will show that the arbor is set at an angle with the base of the fixture, thus holding the work at the proper angle for cutting the spiral teeth.

On the cutting stroke the arbor *A* is rotated through the movement of the screw through the nut *E*. The arbor carries a ratchet *F* which has the same number of teeth as the gear which is to be

milled; and as the arbor revolves one tooth of the ratchet snaps under the pawl *G*. On the return stroke—after the cut has been made—the ratchet and pawl prevent the arbor from turning back to its original position, and to provide for the return of the arbor the nut *E* is allowed to rotate as the arbor is drawn through it. From this it will be seen that the nut can turn backward but is held against rotation in the forward direction, while the ratchet and pawl prevent the arbor from turning backward. As the nut turns, it carries with it the sleeve *H* and index dial *I*, thus indexing the work automatically, ready for milling the next tooth when the arbor again moves forward.



Fixture for Rapid Cutting of Spiral Gears on Hand Milling Machine

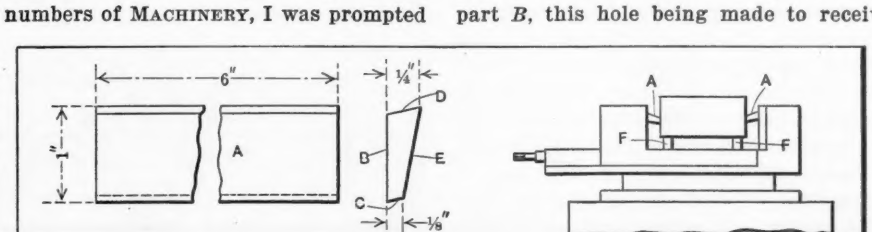
The milling cutter is raised from the work during the return stroke of the arbor by means of a lever provided on the machine for this purpose. When the cutter is raised the index plunger *J* is also automatically withdrawn from the notch in the dial by the same movement. This is accomplished by the mechanism at the back of the fixture. A pin *K*, which is pressed into the housing of the milling machine spindle, travels up and down when the cutter is raised or lowered; and this pin carries the connecting-rod *L* with it. By means of the two arms *M* and *N* and the shaft *O*, the motion is transmitted to the index plunger *J*. The torsion spring *P* insures having the index plunger enter all the way into the notch in the dial. When it is required to raise the cutter high enough to remove the finished work and replace it by a fresh blank, the connecting-rod *L* is swung away so that the pin *K* lies in the clearance slot and the cutter can then be raised as high as necessary.

Th connection between the operating lever *C* and the arbor *A* is a ball joint *Q* which permits of a swinging action of the link *R* in addition to allowing a rotary motion of the arbor. There is an adjustable bearing *S* at the front end of the arbor to provide compensation for wear. The split nut *E* is also made adjustable, compensation for wear being secured by tightening the taper sleeve *T*. The sheet metal cover *U* serves the double purpose of providing a safeguard over the moving parts and excluding chips from the mechanism. All the operator has to do after clamping the work in place on the arbor is to alternately push the lever *C* to feed the work under the cutter and then pull the lever on the milling machine to raise the cutter away from the work, after which the lever *C* is pulled back to return the arbor and index the work ready for the next cut, and the machine lever is then operated to return the cutter into the operating position.

Detroit, Mich. R. A. Black

PLANING A BLOCK SQUARE

After reading the articles of this title published in the October and February numbers of Machinery, I was prompted to write the following description of a simple little tool which I use when planing up castings that require two opposite sides to be exactly parallel. As the castings are generally tapered slightly on the sides, owing to the clearance allowed for removing the pattern from the mold, difficulty is experienced in holding the casting down in the vise. The device used to overcome this trouble consists of a pair of tapered strips *A* which are made of tool steel and planed straight on the bottom side *B* with the edges *C* and *D* parallel to each other but at an angle of about 2 degrees with the side *B*. The side *E* is planed to form an edge about 1/8 inch wide at *C*, which allows the holding of thin pieces of work if necessary.



Hold-down Strip for Use in planing up a Square Block, and Way in which these Strips are used

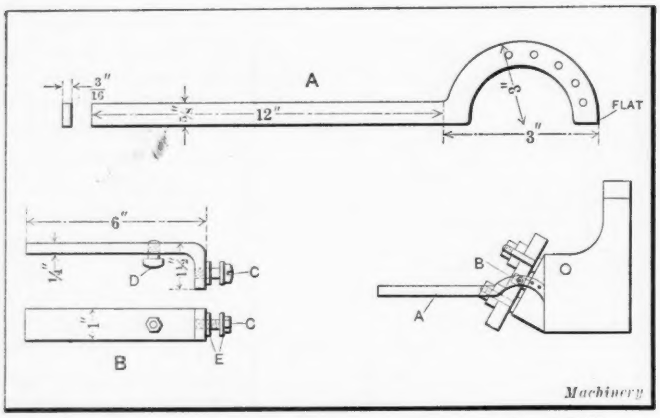
When placing the work in the vise, one of the strips *A* is placed between each jaw and the work, as shown in the small view at the right-hand side of the illustration. The small edges *C* of each of the strips are in contact with the work and the sides *B* are underneath. Under these conditions, it will be found that the work will be held down tightly against the bottom of the vise; after planing one side the work is turned over and two parallels *F* are put under it. The strips *A* are then used in the same way as before, and the vise is tightened to hold the work for planing the second side. A convenient size for these strips is about 1 inch wide by 6 inches long with the thick edge *D* about 1/4 inch wide. The time spent in making a pair of these strips is very slight in comparison to the time spent in forcing the work down into the vise only to have it spring up and result in the production of a defective job.

Pittsburg, Pa. Fred Boehmer, Jr.

A T-SLOTTING KINK

When T-slotting, planer operators in many shops attach an extension stud to one of the tool-post studs which is used to raise the tool-post and hold it up clear of the work while the table is making its return stroke. This is not nearly such a convenient method as the one which can be used in connection with the tool that I am going to describe for the benefit of readers of Machinery.

The part *A* of the tool is made of a piece of 5/8 by 3/16-inch cold-rolled steel 16 inches in length, with one end bent to form a semicircle of 3-inch radius. A flat 1/4 inch in width is ground at the outer end of this semicircle and five holes 1/4 inch in diameter are drilled in the positions shown in the illustration, the distance between the centers of the hole being 1/2 inch. The part *B* is made of a piece of 1 by 1/4 inch cold-rolled steel 7 1/2 inches in length; but the thickness required will differ if the serrated pads on the tool-post are other than 9/32 inch in height. The piece *B* is bent over at one end, as shown in the illustration, and two 1/4-inch holes are drilled and tapped in it. One of these holes is located midway between the base and the top of the perpendicular arm of part *B*, this hole being made to receive the pivot on which part *A* is mounted. The first hole in part *A* was made to give the tool-post a slight lift when the lever *A* is pushed down and comes into contact with the clapper box.



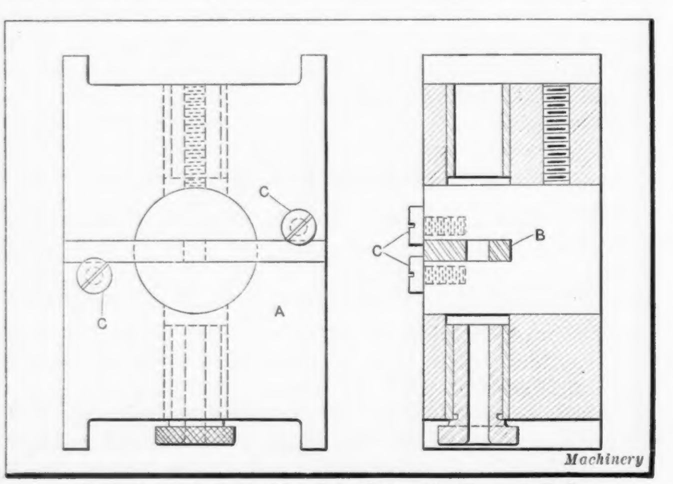
Lifter for raising Tool from Work during Return Stroke of Table

A second hole is drilled and tapped in the part *B* to fit a ¼-inch set-screw, this hole being drilled so that when the part *B* is slipped behind the tool in the tool-post ample room will be left for the movement of the tool. The set-screw *D* is provided to secure the device to the tool-post. It will also be noticed that there are washers *E* on the set-screw *C* to allow the lever *A* to swing freely on the pivot. To set up this device all that is necessary is to slip the holder *B* into place behind the tool and tighten the set-screw *D*. The lever *A* is then adjusted by placing the set-screw *C* in either of the five holes to provide for swinging up the tool to any required height. It will of course be evident that when the planer tool reverses to make its forward stroke lever *A* is swung up to drop the tool down ready to take its cut.

Covington, Ky. F. AUGUSTINE COLDEHOFF, JR.

DRILL JIG FOR MAKING SHRAPNEL BORING-BARS

In machining 18-pound English shrapnel shells, we experienced considerable trouble with the boring-bars and cutters employed for the operation of machining the inside powder



Drill Jig used for making Interchangeable Shrapnel Shell Boring-bars and Cutters

cup. The boring-bar cutters broke off frequently and this caused a considerable loss of time. The government specifications under which these shells are made require very close dimensions, and in order to provide for replacing broken cutters in the boring-bars and have them capable of working to the required dimensions without preliminary adjustment, it was necessary to provide a jig for drilling the bars and cutters so that they would be interchangeable. The accompanying illustration shows the jig designed for this purpose. The frame *A* is a cast-iron block of convenient size, in which the hole is centrally located and bored to exactly the right size to fit the boring-bar. The cutter *B*—which is to be drilled ready for assembling in the boring-bar—is held in place in the jig by two fillister-head screws *C*. In this way, the cutter is made to locate the boring-bar in the proper longitudinal position in the jig. The hole is then drilled and reamed through the boring-bar and cutter to receive the tapered pin which is employed to hold the cutter in place in the bar. With this jig it has been possible to secure absolute interchangeability of boring-bars and cutters.

Hamilton, Ont., Canada. JAMES HAMILTON

MILLING FIXTURE FOR SPLITTING CYLINDRICAL WORK

The milling fixture illustrated in Fig. 1 was designed to provide a rapid means of splitting cylindrical steel pieces of the form shown in Fig. 2. Referring to the illustration, it will be seen that provision is made for splitting four pieces at a time, but the same form of fixture could be employed for splitting various numbers of pieces. The maximum number will, of course, depend upon their sizes and the capacity of the milling machine on which the fixture is used. Referring to Fig. 1, it will be seen that the fixture consists of a cast-iron base which has steel strips *A* inserted in it. The purpose of these strips will be evident by reference to the diagram of the first and second operations shown at the right-hand side of Fig. 2. Here it will be seen that the cutter is fed a little more than half way through the work, after which

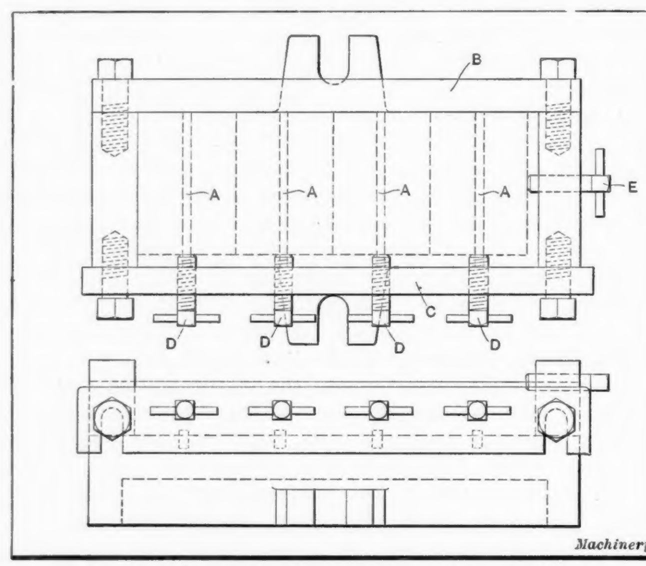


Fig. 1. Milling Fixture for Rapid Production in splitting Cylindrical Work

the work is turned over to enable the milled slot to be dropped over the steel insert in the base of the fixture. This locates the work in position for the second operation which finishes splitting the work into two equal parts.

Referring to Fig. 1, it will be seen that the steel back plate *B* is made separate from the base to which it is secured by two cap-screws. The steel clamping plate *C* is provided with slots so that it can easily be lifted off the cap-screws which secure it to the base of the fixture, to provide for brushing out the chips; and this also facilitates the removal of finished work and the setting up of fresh blanks. The cap-screws which secure the plate to the base of the fixture should be screwed in just far enough to give sufficient clearance to enable the plate to be removed easily when the clamping screws *D* are loosened. When the work to be split is placed in the fixture, the screw *E* is tightened up just enough so that the pieces rest snugly against each other, and the cutters should be set to run 3/16 inch below the center line of the work, so that they do not have to be adjusted to complete splitting the work on the second operation

Toledo, Ohio. WILLIAM H. WOLFGANG

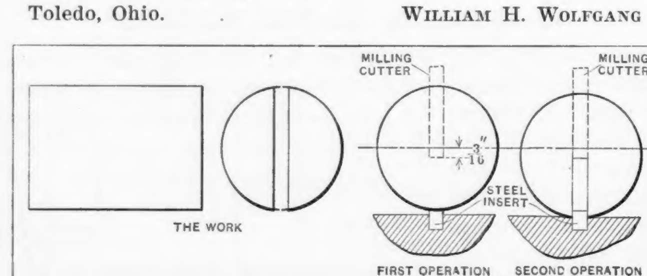


Fig. 2. Work to be split, and Diagrams showing First and Second Operations together with Method of Indexing

CAM INSPECTION FIXTURE

In gas engine factories, automobile plants, and other establishments using large quantities of cams, accurate inspection offers a very difficult problem owing to the length of time that is required to measure up the cams by hand. The device shown in the accompanying illustration performs this operation with accuracy and great rapidity. It consists of a pivoted arm *A* that is raised or lowered by the thrust of the cam which is being tested, and held in contact with the cam by a helical spring. The cam is carried on the shaft *B* which is provided with a key *C*, the cam being slowly rotated by means of a small motor located behind the slate base to which the entire mechanism is fastened.

Connection is made with an electric battery in such a manner that when the cam raises and lowers the arm *A* it closes electric circuits by making contact with the adjusting screws *D*, *E*, *F* and *G*. If the throw of the cam is too slight, no contact will be made with either of the adjusting screws *D* and *E*. If the throw is that desired, contact will be made with the screw *D* and the green electric lamp on the top of the board will flash; if the throw is too great, contact will be made with both the screws *D* and *E* and result in flashing

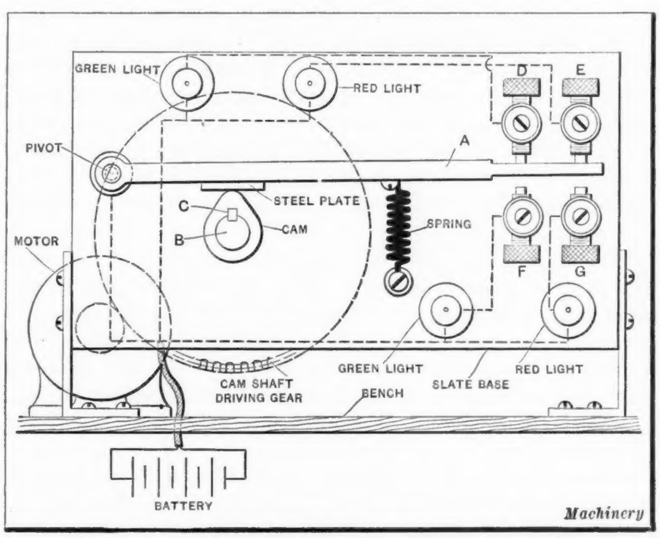


Fig. 1. Cam Testing Fixture: Heavy Broken Lines indicate Concealed Wiring

both the green and red lamps. In the same manner, the lamps at the bottom of the board are flashed; if the diameter of the cam is too great, neither light flashes; if correct the green light shows, and if too small both the green and the red lights show. Fig. 2 shows a detail view of the contact screws. This testing device is adjusted by a master cam which has been carefully measured by hand and found to be perfect. By the use of this device the number of cams that an inspector can test is increased about fifteen times.

Houston, Tex. F. B. Hays

A FLEXIBLE SHAFT COUPLING

A flexible coupling for use on the driving shaft of a motor boat, and for similar classes of service where the alignment is likely to vary, is illustrated herewith. Where this coupling is used the variation of the alignment of the two parts of the shaft must be small, as the coupling is not in any sense adapted to replace a universal joint, its function being merely to compensate for slight errors in alignment of the shaft due to bending, etc. It will be seen that this coupling differs from

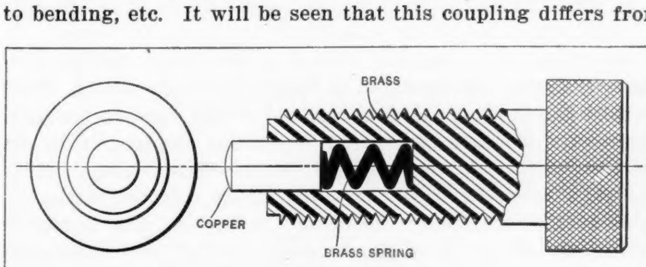
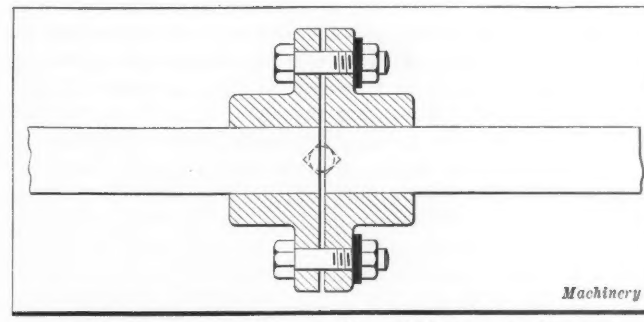


Fig. 2. Detail of Contact Screws



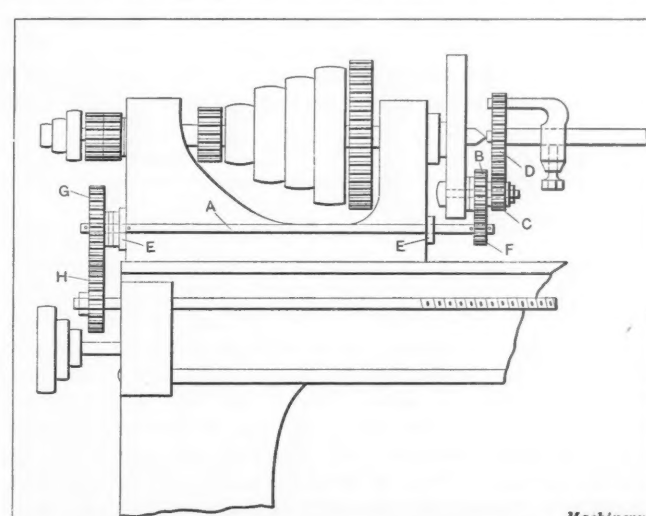
Flexible Shaft Coupling for correcting Slight Errors in Alignment

the ordinary type of flanged coupling in that a steel ball is placed between the ends of the shafts, which are drilled in such a way that less than half of the ball drops into each hole. As a result, the two coupling members are slightly separated and the bolts may be tightened up as required by various errors of alignment. Varying the depth of the holes drilled in the ends of the shafts, and the diameter of the ball, will determine the error in alignment that can be compensated for. In assembling the coupling, the flanges are first put on the shaft as usual; then the two flanges are brought together with the ball in place and secured by bolts in the manner shown. Rubber washers are placed under the nuts and these washers are compressed and expanded as the shaft rotates.

Owego, N. Y. Sidney K. Eastwood

CUTTING COARSE THREADS ON A STANDARD LATHE

It was required to refinish a double threaded worm with a lead of 7 inches, and former attempts to do this on the milling machine had not produced a satisfactory surface on the work. As a result, we decided to try to handle this job on a lathe and eventually selected a standard 16-inch machine for this purpose which was rigged up as shown in the ac-



Arrangement of Special Gearing for cutting a Worm of 7-inch Lead on a Standard Lathe

companying illustration. The power was applied directly to the lead-screw, from which it was transmitted to the arbor on which the work was supported by means of gearing and a special shaft *A*. The spindle of the lathe was locked to prevent it from rotating, and it carried a large faceplate in the usual way.

The necessary gearing for driving the arbor was attached to the faceplate. For this purpose, an intermediate stud taken from the quadrant of another lathe was secured in one of the faceplate slots and the first gear *B* placed on this stud had 90 teeth, while the second gear *C* had 24 teeth. A 96-tooth gear *D* taken from the change gears was fitted to the end of the arbor, the arbor being allowed to project slightly through the gear to bring the latter into line with the 24-tooth gear or stud. The arbor was driven by a dog so arranged that the end of the bent tail would pass through the spokes of the gear *D*, care being taken that the tail of the dog

did not extend too far beyond the spokes of the 96-tooth gear.

Connection was made between this set of gears and the regular change gears of the lathe by means of a piece of 1-inch cold-rolled shafting *A* which was held in place by passing through holes drilled near the ends of two iron straps *E* made of 2 by ½ inch stock; these were clamped to each end of the headstock by means of long bolts reaching from one strap to the other. A 30-tooth gear *F* was used on the faceplate end of the temporary shaft and an 84-tooth gear *G* on the opposite end, these gears being obtained from the change gear set. The 84-tooth gear was arranged to mesh with the gears on the quadrant, while the 30-tooth gear was brought into mesh with the 90-tooth gear *B* carried on the faceplate. As the shaft had to transmit only a little power, a single pin was used for driving each gear, the pin being simply driven into the shaft and filed off to serve as a key.

Washers were placed between the 84-tooth gear and the left-hand strap *E* which forms one of the shaft bearings, a cotter pin at the right-hand side of this bearing acting in conjunction with another cotter pin at the left of the 84-tooth gear to effectually prevent endwise motion of the shaft. The 30-tooth gear on the faceplate end of the shaft had a cotter pin on each side of it. A 24-tooth gear *H* was put on the lead-screw, making the ratio of the train of gears $\frac{24}{84} \times \frac{30}{90} \times \frac{24}{96} = \frac{1}{42}$. Then with the lead-screw having six threads per inch, the required lead of 7 inches was obtained for the work that was to be refinished.

Power was applied to the lead-screw by throwing in the regular slip gear, connecting the lead-screw to the feed cone. The feed cone was brought into line with the large step of the main driving cone on the overhead countershaft by sliding the lathe endwise on the floor, and when connected up it was found that a 1-inch belt provided ample power. The length of the worm to be finished was 8½ inches and the carriage was set to travel 10½ inches, after which the lathe was stopped and the carriage returned by hand. This brought alternate threads on the worm into position to be cut. The feed of the cutting tool was obtained by using the compound rest which was set to afford the desired angle on the sides of the worm thread.

Scranton, Pa. LUTHER C. SCOTT

DEVELOPING A NEW MACHINE

In looking over the March number of MACHINERY, my attention was caught by James Dangerfield's article entitled "Developing a Typewriter." With the amount of information given in this article it is difficult to form a reliable opinion, but my experience in the development of new machines leads me to believe that $1400 was excessive for the amount of work that had to be done, as the "cut and try" method of development is quite likely to be; and the results obtained are almost sure to be less satisfactory than the work done by the experienced designer who has the cooperation of the other members of the staff of the machine building factory.

It has been my privilege to assist in the development of numerous inventions, including some of my own, and this experience has strengthened my opinion that a systematic method of designing is the best possible plan to follow in machine development. The following is a case in point. An exceptionally clever mechanic conceived a general idea for a new article of commercial value, but realizing that its success depended upon a low selling price he set about the development of an automatic machine for use in its manufacture. Now the building of this automatic machine was purely a designing proposition which required no inventive ability; but although this was the case the mechanic spent all of his spare time during four years, and all the money he could save, in building the model. To show how this loss of time occurred it may be mentioned that there were fourteen cams on the machine and the mechanic had cut each of these out of a block of hard wood and then used the wooden cam as a pattern.

While on the subject of cams the writer recalls a case in which he was engaged to redesign a machine in which a number of cams were used. In doing this work an operation sheet was made, from which all the cams were laid out in the proper relation of the keyways. The superintendent of the shop in which this machine was made was one of the old school of mechanics who had to fit everything in order to be sure that it was right, and he flatly refused to "spoil" all of these cams by keyseating them before they were properly timed on the shaft. It was finally necessary to go to the general manager before the superintendent could be induced to follow instructions; but when he was finally won over and the work was done it is needless to say that the results were entirely satisfactory.

In machine developments, above all things, it is impractical to follow any one general rule; but there are certain principles which may be generally applied with satisfactory results. These may be briefly outlined as follows: First, be sure there is a market for the product or that a market can be developed after it has been perfected. Second, procure the services of a high-grade machine designer or of a machine development organization of recognized ability to perfect the idea. Third, build a model and try it out under the most adverse working conditions; and while conducting this part of the work note all possible points of weakness in the construction or method of operation. Fourth, redesign the machine with a view of overcoming all points of weakness which have been discovered, paying particular attention to all points which will affect the cost of the finished machine when it is made on a manufacturing basis. Fifth, build a second model and put it to work under actual conditions for at least six months.

If at the end of this trial period the machine has demonstrated that it is of practical value, the time is ripe to consider the design of tools and the development of the methods for manufacturing the machine for the market. An inventor should rarely, if ever, be allowed to pass on the practical value of a machine or have a voice in the selection of methods of manufacture, as he will quite naturally cling to certain refinements which are of no practical value, and which add to the cost of the finished machine. To be at all sure of success, the best plan is to work slowly, to endeavor to profit by the other fellow's mistakes, and to keep "everlastingly" at it, always bearing in mind that paper, pencils and erasers are far cheaper than metal and machine work.

Woonsocket, R. I. WILLIAM C. GLASS

FIXTURE FOR MACHINING MOVING-PICTURE MACHINE CROSS-PINS

The piece shown in Fig. 1 is known as a "cross-pin" and is used on a moving-picture machine to carry the sprocket that moves the film past the aperture plate. The cross-pin is indexed through an angle of 90 degrees sixteen times per second by means of a cam which engages the short pins; and owing to the severity of the service it was found that the shaft, head and pins had to be made in a single piece. The location of the projecting pins has to be extremely accurate because the picture is magnified 250 times and sixteen pictures are shown per second. The light is shut off between each picture, and if an error occurred in the spacing of the pins it is evident that the succeeding pictures would not be shown in the same location on the screen. As the error would be magnified 250 times, an error of 0.001 inch in the pins would cause the pictures on the screen to jump through ¼ inch, which would be excessively trying to the eyes.

According to the original method of production, ten machining operations were involved in finishing the cross-pins. This method had several bad features, and as the demand for moving-picture machines increased it became imperative to develop a more efficient method of producing these parts. Several ideas were tried out which finally resulted in the development of the fixture illustrated in Fig. 2. The following operations are involved in finishing one of the cross-pins: first, the work is set up in the fixture and the tail end of the work is faced and centered on the drill press, after which

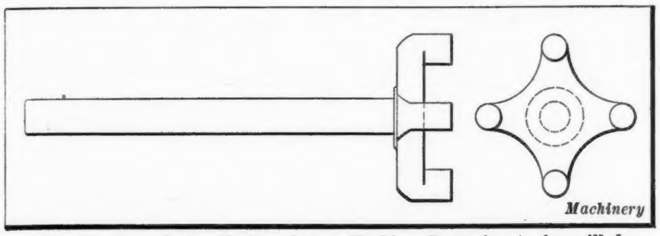


Fig. 1. One of the Moving-picture Machine Cross-pins to be milled

the head end of the work is faced and centered with the lid *B* of the fixture in the working position; the lid *B* is then swung back and the lid *A* raised into the operating position, to allow the four pins to be finished with a hollow mill; second, the shaft is turned to 0.008 inch over size on an engine lathe; third, the back of the head and shoulder are faced on the lathe; fourth, the sides of the head are milled to the required shape; fifth, the head and pins are hardened; sixth, the shaft is ground to size; seventh, the pins are ground to size, a special eccentric fixture being used.

The double lid *A* and *B* provided for the fixture was necessitated by the fact that the five bushings which are necessary could not be carried in a single lid owing to the manner in which their centers are spaced. Using this fixture, the rough forging is set up and the pins are hollow-milled while the shaft has all of its original strength, thus eliminating any tendency to spring the work during the milling operation. Since the finished shaft is only 0.3125 inch in diameter, having an extra 1/16 inch of metal present while the pins are being milled is of considerable importance in assisting the shaft to support the strain of the cut. A knurl-headed plug was made to fit freely in the bushing in the lid *B*, and a slot just large enough to receive the cross-pin was milled in the end of this plug central with its diameter, in order to enable the rough forging to be located in the fixture before the clamp *F* is tightened.

Holders were made to fit the bushings *C* and *D* to hold an ordinary combination center drill and reamer. The center drill was ground off rather short to avoid the chance of breakage. Special facing mills were made to fit the bushings, and as the centering was done first the mills did not have to cut right to the center. Suitable hollow mills were also made for finishing the pins, these mills entering the bushings in the lid *A*. All of the tools were provided with adjustable stop-collars which make contact with the bushing heads. Great care was taken to have the bushings and V-blocks properly located. The clamping device *F* afforded a rigid method of securing the work without permitting any tendency toward twisting or slipping. Two flat springs *E* hold the lids when they are swung down out of the way.

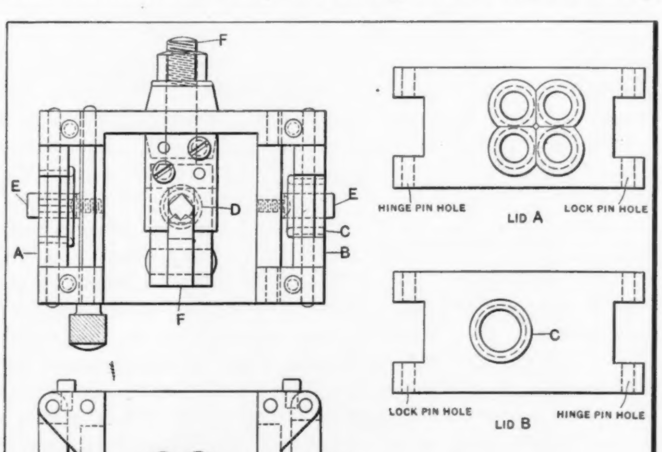


Fig. 2. Fixture and Detail Views of Lids A and B and Clamp F

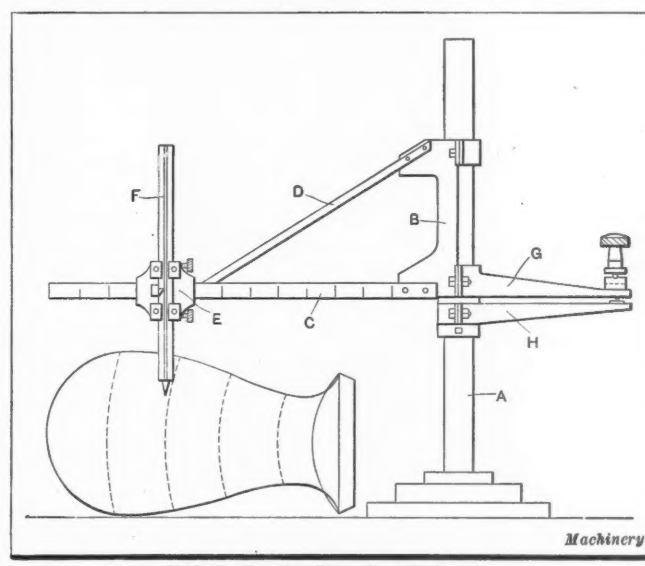
It was found that this fixture reduced the cost of producing these parts 40 per cent, and the saving effected in machining the first three hundred pieces paid for the new tools.

Caldwell, N. J. HARRY G. THAYER

THE PITCHOMETER AND ITS USE

The accompanying illustration shows a novel and convenient device for measuring the exact pitch of propeller blades. This device is a refinement of many crude fixtures made by different foremen of the machinery division of the Boston Navy Yard, and it has proved very useful in connection with the machining of built-up propellers, as it is a simple matter to establish the center line of the blade, as well as the shaft line. It will be noticed that the illustration shows a single blade set up under the arm and adjusted to the required pitch. Having the blade set up to the required pitch, the steel square is placed on the platen and a line erected through the center of the palm, which will be used for establishing the lay-out for the bolt holes as well as for setting up in case the blades are to be planed.

The general construction of this pitchometer is as follows: The tube *A* is about 5 inches in diameter with walls 1/4 inch thick, the bottom end being turned tapering and fitted into



Method of using Propeller Pitchometer

the cast-iron base. The tube is threaded and has a nut fitted at the bottom for the purpose of removing the tube from the base. The tube shown in the illustration is about 8 feet long. The light cast-iron bracket *B* is machined to revolve snugly on the post *A*. Attached to this bracket is a light T-iron *C* and its supporting bar *D*. The part *E* is a light cast-iron head that slides freely on the bar *C* and carries a hard-wood T-bar *F*. Secured to the bar *F* is a 36-inch scale on which the reading can be taken from a pointer shown in the center of the head *E*. It will be noted that the T-bar *C* is graduated, the graduations reading out from the center of the post. A light cast-iron fixture *G* is secured to the bracket *B*, the end of which carries a pointer. This pointer can be notched into the graduations on the quadrant *H*; the quadrant *H* is secured to the post *A* and its upper surface is graduated from 0 to 45 degrees each way from its center.

When testing the pitch of solid propellers the post is simply removed from its base and the hub of the propeller placed on the base, after which the post is inserted. The operation of measuring the pitch of a propeller is as follows: Place the slide *E* at the required diameter and then set the quadrant graduations at 0. See that the pointer rests on the blade surface and note the measurement on the scale; then swing the arm through 15 degrees, drop the pointer until it comes in contact with the surface of the blade, and the reading may be taken from the scale. For instance, say you find the drop is 8 inches in 15 degrees; by dividing 360 degrees by 15, you will find 24, and multiplying 8 by 24 gives 192 inches or 16 feet as the pitch.

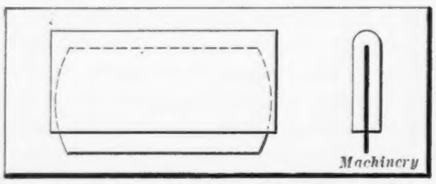
Somerville, Mass. N. I. MOSHER

SHOP AND DRAFTING-ROOM KINKS

INGENIOUS MEANS AND SHORT CUTS FOR SAVING LABOR AND MATERIALS

AN EFFICIENT ERASING KNIFE

The draftsman or tracer who wishes to produce work of neat appearance will avoid making ink erasures as far as possible. But although he may be careful in making his tracings, there will always be a few places where a line extends slightly beyond its connecting line or where the arc of a circle is not exactly tangent to a straight line. In such cases, the use of a coarse ink eraser will not only mar the drawing, but it will frequently necessitate patching the tracing at the point where the erasure was made.



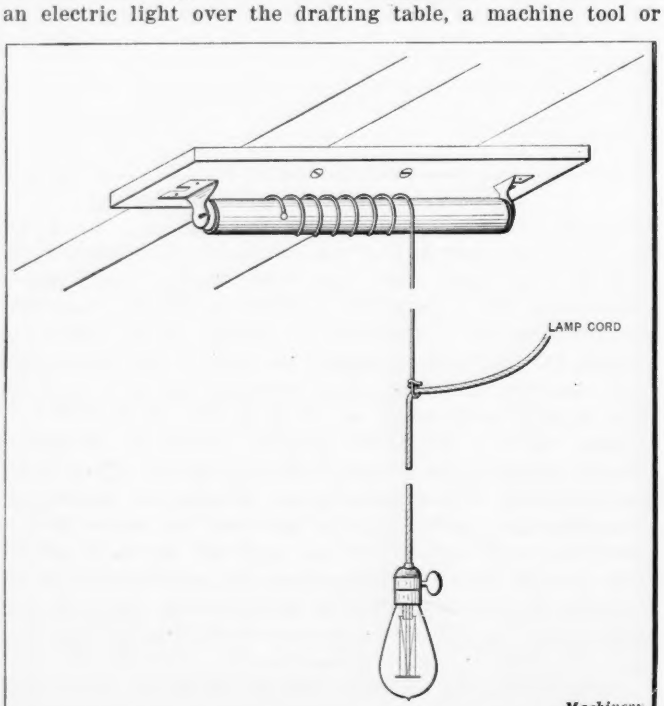
Erasing Knife made from Safety Razor Blade

Where there is not too much ink to be removed, it is best to scrape the ink off before starting to use a rubber. This can be done with a pocket knife if it is kept very sharp, but I have obtained much better results by the use of a discarded safety razor blade. With a pocket knife or other instrument which has not an exceedingly keen edge, it is difficult to remove the ink without scratching into the cloth. But with the safety razor blade, the coating of ink can be scraped off without damaging the cloth in any way. The four corners of a double edge blade can be used for a long time and the blade can be fastened into a holder to protect the fingers.

McKees Rocks, Pa. A. H. Anger

LAMP CORD ADJUSTER

The accompanying illustration shows an inexpensive form of lamp cord adjuster for use in regulating the position of an electric light over the drafting table, a machine tool or



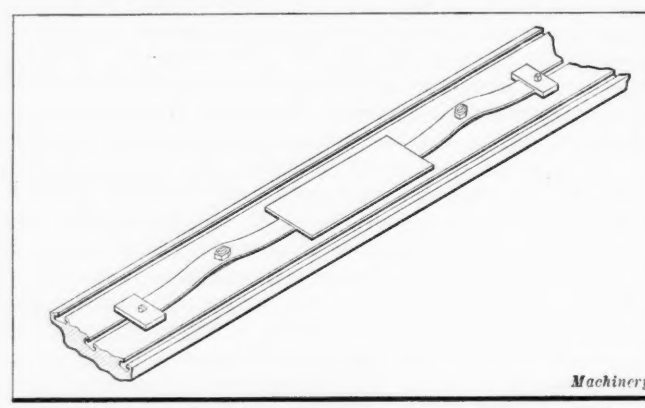
Use of a Window Shade Roller as a Lamp Cord Adjuster

any other location where good lighting is essential. This consists of an ordinary window-shade roller, cut as short as the spring will allow and fastened to the ceiling or any other convenient support. One end of a strong cord is attached to the lamp wire and the other end to the roller. Then the lamp can be adjusted by raising or lowering it the same as a window shade. Some forms of lamp cord adjusters have a tendency to destroy the cord, but the one here described has no destructive effect on either the wires or installation.

South Norwalk, Conn. E. J. Erickson

SPRING CLAMP FOR THIN WORK

Possibly some readers of Machinery who occasionally have to do a surface grinding job without the aid of a magnetic chuck will be interested in this description of a spring clamp which we use for work that is too thin to permit of the use of a regular clamp or too large for the vise. The work is laid loosely between two strips of cold-rolled steel about 1½ inch wide by 1/16 inch thick. The ends of these flat strips which come next to the work are supported on cross wires laid alongside of the work; and the opposite ends of the strips abut against blocks which are bolted down securely to the table. After the nuts which hold the strips have been tightened, the work is rapped down to secure a bearing on the table, after which the cross wires are pulled



Spring Bunter for holding Thin Work, where a Magnetic Chuck is not available

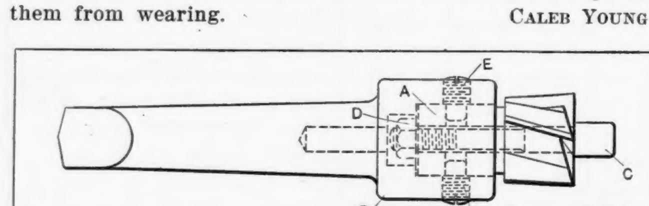
out to allow the strips to spring down. It will then be found that the work is held firmly in place. As compared with any other method which we have tried, this clamp possesses the advantage of being simple and of having no parts which are likely to be accidentally struck by the wheel.

Brooklyn, N. Y. John Huntting

A USEFUL FORM OF COUNTERBORE

The counterbore shown in the accompanying illustration is one that has been successfully used in our shop and given less trouble than any other type that we have tried. The parts of this counterbore are made interchangeable so that it is possible to assemble them in various combinations. The shank *A* of the cutter fits into the holder *B* with the end of the shank bearing against the shoulder in the holder which carries the thrust; and it will also be seen that the neck of the shank is slightly under-cut to facilitate grinding. The comparatively long shank of this counterbore insures perfect alignment, and yet the over-all length is only about 2 inches, which means quite a saving in the cost of tool steel. The teeth of the cutter have a rake of 15 degrees and are formed to make them free-cutting on practically any material and still afford the necessary strength and chip space. As the cutter is ground, the pilot *C* can be taken up by means of the nut *D* which bears against the back of the cutter, allowing the threaded end of the pilot to enter a hole in the holder. This holder or driver is made of mild steel carbonized and hardened, and carries two screw pins *E* which enter corresponding holes in the shank of the cutter. These pins are of ample size to drive the cutter and are hardened to prevent them from wearing.

Caleb Young



A Useful Type of Counterbore

NEW MACHINERY AND TOOLS

THE COMPLETE MONTHLY RECORD OF NEW DESIGNS AND IMPROVEMENTS IN AMERICAN METAL-WORKING MACHINERY AND TOOLS

CURTIS AUTOMATIC SHRAPNEL-SHELL CUTTING-OFF MACHINE

The features of this machine are that the cutters are fed in and returned automatically, the operator merely being required to place the rough forgings in the machine and remove the trimmed shells. The cutter head carries four cutters which work simultaneously, and enable a high cutting speed to be employed. As the cutter head rotates and the heavy work remains stationary, the consumption of power is reduced to a minimum. One operator can attend to three machines, each of which has a capacity for trimming from forty to sixty shells per hour.

Those manufacturers who are working on orders for shrapnel shells find high-speed production of more than usual importance, due to the fact that most of the contracts call for the delivery of large numbers of shells at frequent specified intervals. As a result, machines which are to give satisfactory service must turn out the work with the greatest possibile rapidity. Shrapnel manufacturers who are making shells by the forging process will find that this point has been particularly well provided for in the automatic cutting-off machine which has been placed on the market by the Curtis & Curtis Co., 8 Garden St., Bridgeport, Conn. With this machine, the work of cutting off the rough edges of the forged shells to reduce them to standard length can be done very quickly.

Front and rear views of the Curtis cutting-off machine are shown in Figs. 1 and 2. In the operation of this machine the workman is merely required to place the rough forging in the vise and tighten the movable jaw by means of a capstan wheel at the top of the machine. The feeding of the cutters into the work is automatically controlled by a

Fig. 1. Curtis Automatic Machine for cutting off Forged Shrapnel Shells to Standard Length

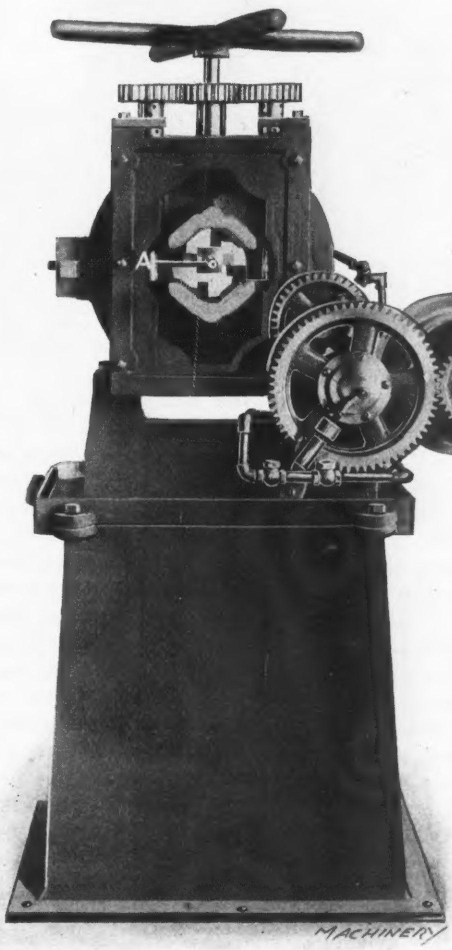


Fig. 2. Operating Side of Machine, showing Length Stop which locates Work in Vise

continuous cam, which feeds them in at a uniform speed, and returns them at high speed after the cut has been completed. The cutters then start at once on their next stroke without requiring the machine to be stopped. The cam employed for this purpose is shown in Fig. 3. The maximum travel of the cutters is ½ inch, which provides plenty of time in which to put in and take out the work, and compensates for irregularities in the thickness of the rough shrapnel shell forgings. A stop-bar *A* carried by the bracket shown in Fig. 1, locates the shell ready to be trimmed down to the required length. This stop-bar extends back through the vise and comes up against the inside of the base of the shell to locate it for cutting off. The rough shells can be delivered down an inclined chute to the machine, so that the attendant does not have to leave the operating position at any time.

In these machines, the principle of rotating the light cutter head around the heavy work has been adopted, rather than rotating the heavy work inside of the cutter head. This is the means of reducing the amount of power required to drive the machine to a minimum. The cutter head is driven by a gear meshing with a pinion on the driving shaft *B*, and a second pinion carried on the outer end of the same shaft engages with gear teeth cut in the periphery of the feed cam. The ratio of these gears is such that the feed cam runs slightly faster than the cutter head, thus providing the necessary relative motion to permit the cam to feed the cutters into the work, and return them at high speed, in the manner which has already been described. This cam mechanism is a patented construction. The cutters are arranged in two pairs, one pair being pointed and the other square, in order to break up the chips and enable them to

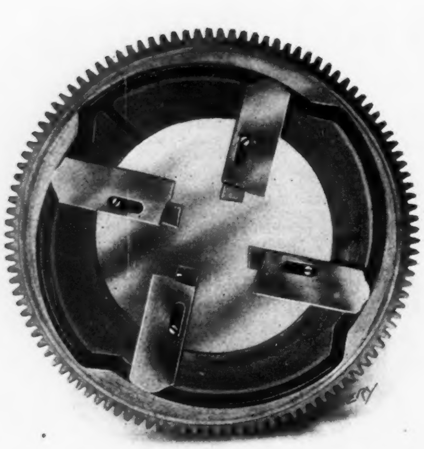


Fig. 3. Cam that controls Continuous Feed, on which a Patent has been granted

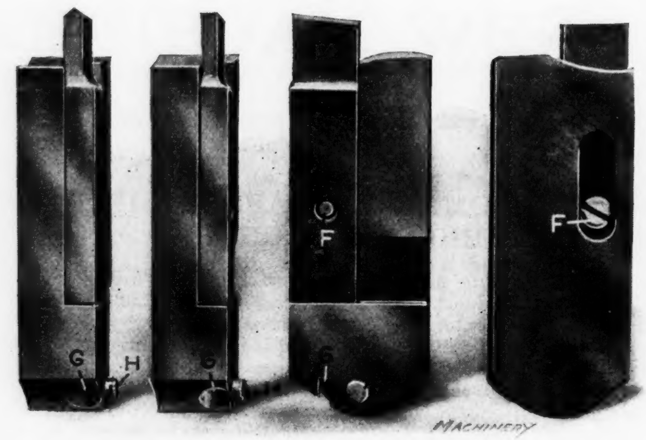


Fig. 4. Cutters removed from Head to show Adjusting and Clamping Screws; one Pair of Cutters is Sharp and the other Square

clear easily. This is in accordance with the best practice of designing tools for cutting-off machines.

It requires 1½ minute for the cam to feed the cutters in to the end of their stroke and return them to the starting position. Of this time, forty seconds is required for making the cut, leaving fifty seconds for the operator to remove the trimmed shell from the vise and replace it by a fresh forging. This is more time than is actually required, a liberal allowance having been made so that one operator will have plenty of time when operating more than one machine. The pinion which meshes with the gear that drives the feed cam is provided with a clutch shown at *C* in Fig. 5, so that the machine may be set to complete its cutting stroke at any desired time, relative to the time at which other machines in the same battery complete their cutting strokes. It has been mentioned that one operator can attend to a battery of three machines, and the provision of this clutch for synchronizing the machines is to enable the cutting strokes to be completed in rotation, so that the operator can move from machine to machine and replace the trimmed shells with fresh forgings, as fast as they are required. In this way, both the machines and the operator are kept constantly employed.

The speed of the machine is limited only by the rate at which the high-speed steel cutters can be run without requiring an excessive amount of regrinding. Machines can be built to provide any speed or feed which is required, but unless otherwise specified they will be designed for a cutting speed of 20 feet per minute, and timed to cut off a 3¼-inch shrapnel shell forging in forty seconds, giving a capacity of from forty to sixty shells per hour. Referring again to Fig. 3, which shows the cam for feeding the cutters in to the work, it will be seen that there is a groove *D* in the cam that receives a pin *H*, Fig. 4, on each of the cutter holders, to provide for holding them in contact with the cam surface. It will also be noticed that there is a transverse groove *E* which enables the pins to leave the retaining groove. This is provided for the purpose of removing the cutters from the cutter head when they need sharpening. For this purpose the faceplate of the machine has four graduations spaced 90 degrees apart. When one of these graduations is brought into coincidence with the index mark on the cutter head, it means that the groove in the cam is in such a position that one of the cutters can be removed.

Fig. 5. Machine with Faceplate and Cam removed to show Drive for Cutter Head

The four cutters are shown in detail in Fig. 4. It will be seen that holders are provided for carrying high-speed steel blades. As the blades are ground it will be evident that compensation must be made for the amount of metal which has been removed. This is done by first loosening a binding screw *F* in the holder and then screwing in the backing-up screw at *G* to bring the cutter into the required position. After this has been done, the binding screw *F* is re-tightened to secure the cutter in place in the holder. The regular equipment of the machine includes a countershaft, oil pump, and one set of adjusting tools. The approximate weight is 1200 pounds, and the floor space required is 36 by 24 inches. In addition to its application in cutting off shrapnel shells, the machine is adapted for working on all classes of tubular stock; and when cutting such material it can work at a much higher speed.

NILES-BEMENT-POND PROJECTILE LATHES

These are standard Niles-Bement-Pond tools fitted with special attachments to adapt them for projectile work. The machine shown in Fig. 1 is a 26-inch lathe equipped with a boring tailstock for machining high explosive shells. In Fig. 2, a 30-inch lathe is shown equipped with an attachment for cutting the waves and grooving the band seats in shells. Fig. 3 shows a 36-inch lathe with the boring bar mounted on the carriage and arranged for boring either straight or taper shells.

The standard engine lathe can be made more efficient on shell work when equipped with certain special attachments. These attachments can be readily removed at any time and standard parts applied, thus making the machine ready for any regular engine lathe work. The Niles-Bement-Pond Co., 111 Broadway, New York City, is furnishing its lathes equipped with several types of attachments which adapt them for high production of duplicate work in the finishing of shrapnel and all sizes of high explosive shells, both of the solid and hollow forged types.

Boring Tailstock

Fig. 1 shows a 26 inch double back-geared engine lathe equipped with a boring tailstock for boring high explosive shells, either from the solid bar, or where the shells to be bored are of the hollow forged type.

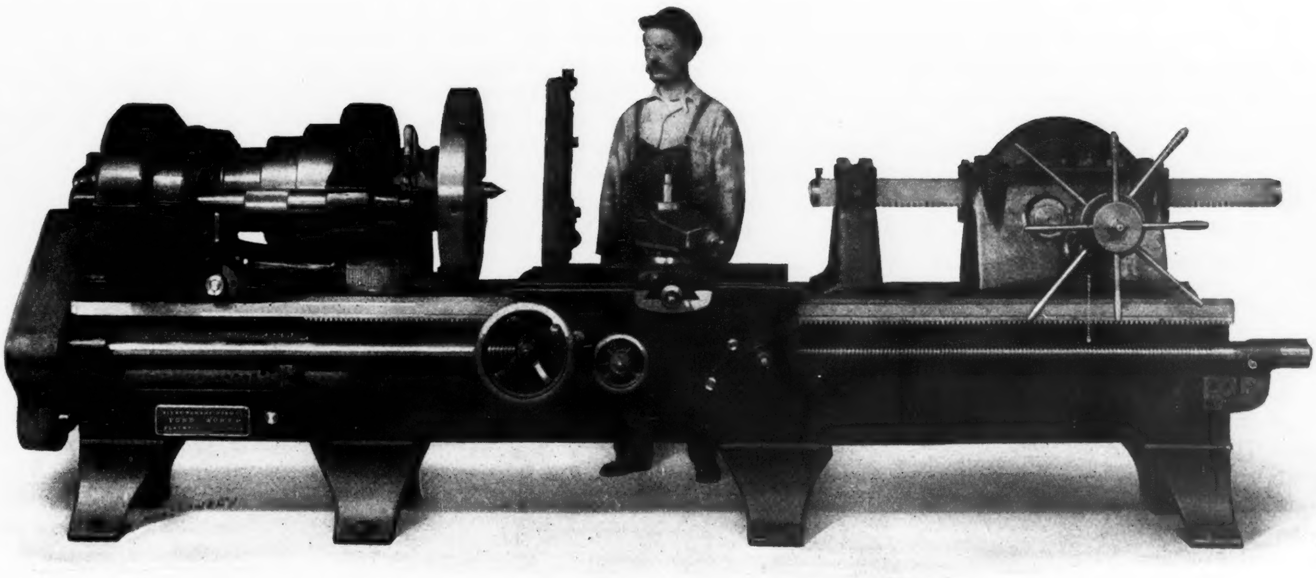


Fig. 1. Niles-Bement-Pond 26-inch Double Back-geared Lathe equipped with Boring Tailstock for machining High Explosive Shells

With the exception of the tailstock, the lathe is the standard type with certain improved features incorporated in the design. The boring tailstock and support can be readily removed and a standard tailstock applied for regular lathe work. The interior contour of the shell is obtained by the use of bottoming and forming tools built to suit the requirements of each individual job that is handled.

The tailstock is fitted with a square forged steel boring ram which has power feed transmitted by a shaft geared to the driving works and running along the rear of the bed. The shaft drives through a worm and worm-wheel to the pinion and rack on the ram, which gives a smooth positive motion. Large pilot wheels are provided for hand traverse of the ram and for starting and stopping the feed. The lathe is equipped with a quick-change gear feed mechanism. To prevent vibration of the tools, the boring ram is provided with a support which can be adjusted along the bed to a position near the work. The lathe is also equipped with a standard tool carriage for turning operations; and there is also a steadyrest for supporting either a pot chuck or the shell itself as the case may be.

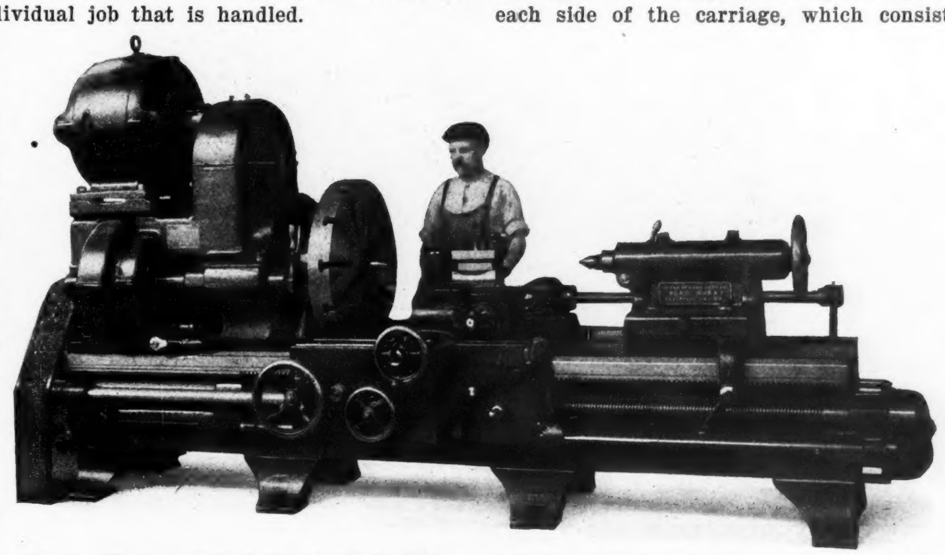


Fig. 2. Niles-Bement-Pond 30-inch Double Back-geared Lathe equipped with Attachment for cutting the Waves and Band Seats in Shells

Attachment for Straight or Taper Boring

Fig. 3 shows a 36-inch triple-geared engine lathe equipped with a boring-bar mounted on the carriage and arranged for either straight or taper boring of shells. The boring-bar is carried in a bearing with a swiveling base mounted in the carriage. Two supports are provided for the bar, one on each side of the carriage, which consist of a bearing for the bar mounted on a slide which has cross adjustment on a substantial base. For taper boring, the support near the shell is shifted to one side of its central position and the other end support shifted to the other side of its central position. The support bearings have means of swiveling through a sufficient range for all classes of shells. The central bearing of the bar is arranged to slide in and out on the carriage with the bar. The bar can be adjusted bodily across the lathe so that the cutter can be traversed inside the shell and fed into the work, and at the same time always remain at a given taper. This is accomplished by having the slides of the supports connected by screws and gearing so that they move together when adjusted by the wrench shown on the support nearest the headstock.

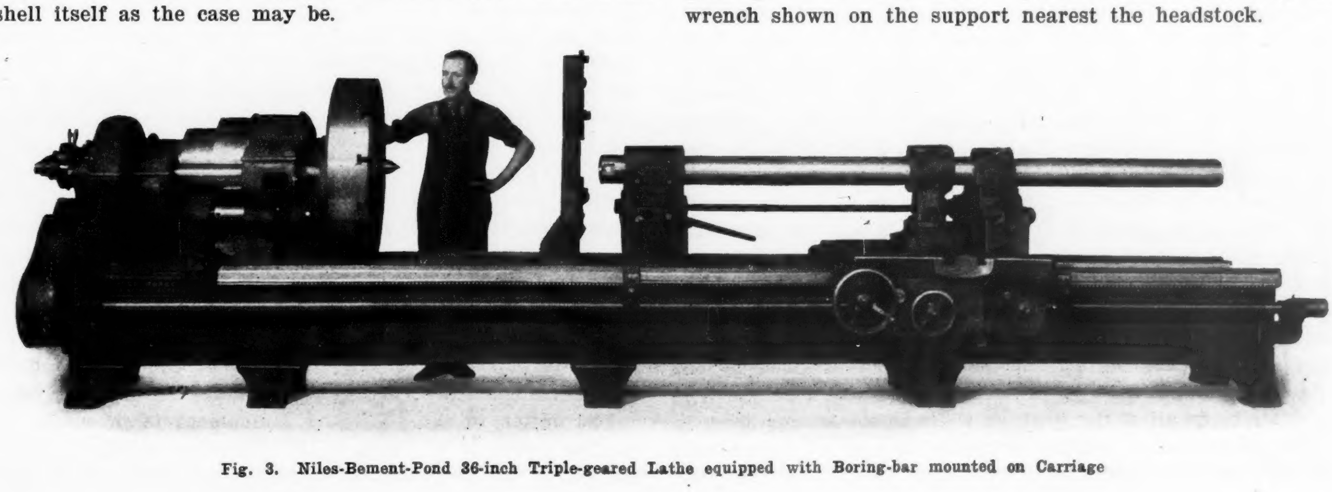


Fig. 3. Niles-Bement-Pond 36-inch Triple-geared Lathe equipped with Boring-bar mounted on Carriage

Attachment for Cutting Waves and Grooving Band Seats

Fig. 2 shows a 30-inch double back-geared lathe equipped with an attachment for cutting the waves and grooving the band seats in shells. The standard compound tool-rest has been removed from the carriage and a special rest substituted. This consists of a lower slide which is mounted directly in the carriage and has cross adjustment by a hand screw. Mounted on this lower slide there is a tool-slide. In order to obtain the wave effect, this tool-slide is given a reciprocating motion parallel with the bed while the projectile revolves. This motion is obtained by means of an eccentric carried on a cross-shaft which is journaled in the cross-slide. This cross-shaft is driven by bevel gears from a shaft located along the back of the lathe. The latter shaft is geared to the main spindle of the head and suitable change gears are provided for obtaining the number of waves per revolution required on different sizes and types of shells. The eccentric is adjustable to produce the desired amount of wave. The depth of the wave rib is determined by the shape of the formed tool. On lathes equipped with this attachment, it is customary to furnish also a four-sided turret tool-post on the rear of the carriage, as shown in the illustration. This permits all the operations on the band seat to be performed at one setting of the projectile in the lathe.

JACKSON DUPLEX DIE-SINKING MACHINE

This machine is known as the No. 8 Jackson die-sinker and is particularly adapted for working on heavy drop-forging dies of the type used in the manufacture of camshafts, crankshafts, front axles, etc. It differs from other die-sinking machines of this company's manufacture in that the vertical feed is obtained by the travel of the head on the column, instead of employing the knee form of construction. The head is equipped with a vertical spindle and a cherrying attachment.

For use in making the drop-forging dies employed in the manufacture of crankshafts, camshafts, front axles, and similar parts, the Jackson Machine Tool Co., Jackson, Mich., has developed a duplex die-sinking machine which is known as the No. 8 Jackson die-sinker. To provide for supporting the large die blocks required for the class of dies made on this machine, the design has been worked out with the view of obtaining ample rigidity in all parts of the machine. The base is heavily ribbed and contains the gears which provide the changes of speed and feed. These gears are of coarse pitch, and made of hardened high carbon steel. The gears run in oil, and the shafts on which they are carried are hardened and ground. The present machine differs from the smaller die-sinkers of this company's manufacture in that it has no knee, the vertical movement being obtained by the movement of the head on the column. On this machine it is possible to do all of the work on a die at one setting.

The saddle has a bearing 24 inches long by 23 inches wide on the base, and the sides are extended to support the table. The working surface of the table is 18 by 64 inches; it is heavily ribbed and of exceptional thickness. The T-slots have a liberal amount of metal above them so that there is no danger of breakage when heavy strains are applied for holding large work. It will be seen that the head is of the duplex type, in which there is a vertical spindle carried in taper boxes to provide compensation for wear, and a ball thrust bearing to carry the end load. The spindle has a hole through its entire length, so that a draw-in chuck can be used, the hole being No. 13 B. & S. taper. A chuck and five collets are furnished with the machine as part of the regular equipment. The cherrying or secondary head is provided with a vertical movement of about 3/16 inch on the return stroke, so that the cutter is cleared from the work. When not in use, this head is raised about 3 inches so that it is out of the way while the vertical spindle is at work. It will be noticed that the housing of the cherrying head is cut away at the front in order to allow the head to be operated close up to a breakdown when the die on which the machine is working is made in this way.

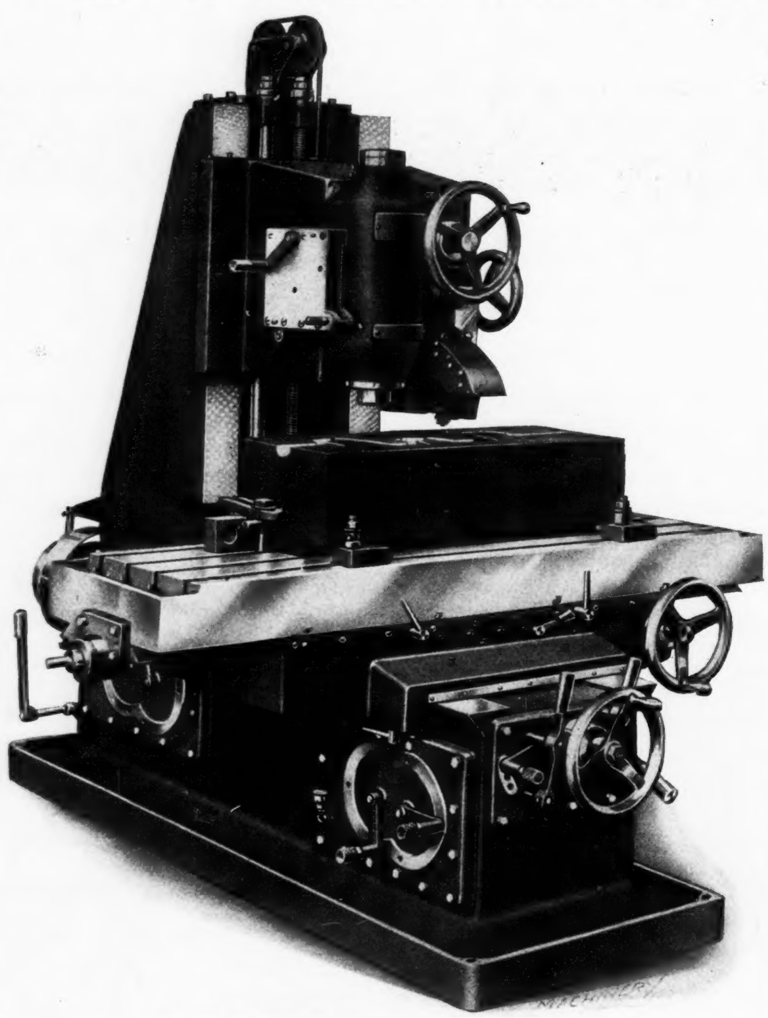


Fig. 1. Jackson No. 8 Duplex Die-sinking Machine

Power is delivered to the machine from the 14-inch Edgemont clutch pulley which should run at 270 revolutions per minute. The clutch can be controlled from either the front or back of the machine, the levers provided for this purpose being shown at *A* and *B* in Fig. 2. The drive is carried to the speed-box *C* where provision is made for obtaining any of nine changes of speed for the spindle or cherrying strokes. Spindle speeds of 45, 64, 84, 110, 157, 206, 270, 385, and 505 revolutions per minute are available. The obtainable strokes of the cherrying attachment are as follows: 15, 21, 28, 36, 52, 69, 90, 128, and 168 strokes per minute. The drive is carried from the speed-box to the head through a train of bevel and spur gears and a vertical shaft, the end thrust of the shaft being carried by ball bearings in the base.

A second shaft leads from the speed-box *C* to the feed-box *D* at the front of the machine, in which gears are provided that give nine changes of feed in all directions, as follows: the vertical feeds per stroke range from 0.0003 to 0.010 inch, and the horizontal feeds from 0.001 to 0.030 inch. The speed reduction is taken care of before reaching the feed-box, so that the feed gears run at relatively slow speeds. All feed motions are controlled by levers located at the front of the table where they are within easy reach of the operator. The cross-feed is controlled at *E*, the vertical feed at *F*, and the table feed at *G*. All feed motions are reversible. The saddle is counterbalanced and provided with hand adjustment in addition to the power feed. The provision of the clutch lever *H* makes it impossible for the operator to engage the cherrying attachment and the vertical spindle at the same time.

The design of the cherrying attachment is shown in Fig. 3. The power is delivered to the cherrying spindle by a link and crank motion which is operated by a cam. This repre-

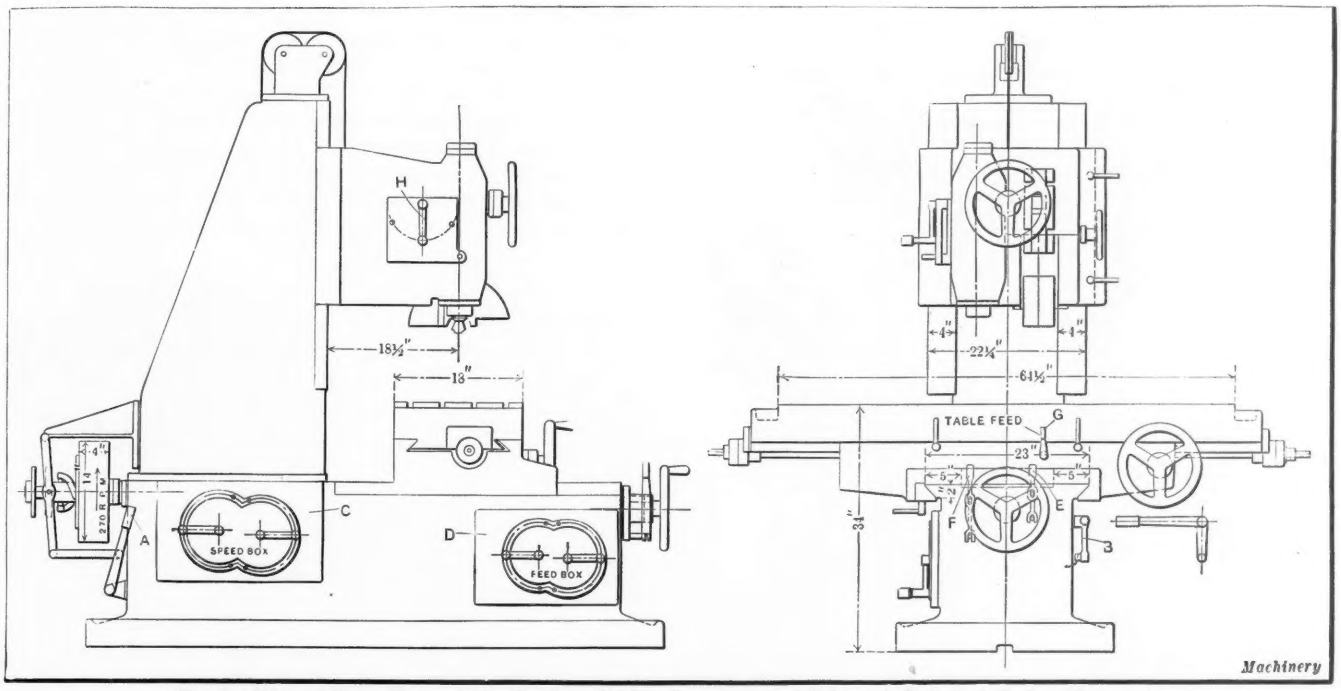


Fig. 2. Side and Front Views of the Machine, showing Arrangement of Drive and Control of Various Movements

sents a departure from the design employed on other die-sinking machines manufactured by the Jackson Machine Tool Co., in which the motion is obtained through a rack and pinion. The cherrying attachment can be raised by the hand-wheel *J* and held up by the locking pin *K*, so that it is flush with the base of the saddle and does not interfere with the working of the vertical spindle. It will be seen that a square section has been cut away from the cherrying attachment at *L* to allow the cutter to operate close up to a breakdown when dies are so made. A vertical movement of 3/16 inch is provided for the cherrying cutter so that it clears the work on the return stroke.

The principal dimensions of the Jackson No. 8 die-sinking machine are as follows: vertical movement of head, 22 inches; cross travel of table, 18 inches; longitudinal travel of table, 56 inches; working surface of table, 18 by 64 inches; distance from center of spindle to face of column, 18½ inches; size of driving pulley, 14 inches diameter by 4 inches face width; capacity for driving cutters from ¼ to 4 inches in diameter; and net weight of machine, 8000 pounds. If the machine is arranged for individual motor drive, a five-horsepower constant-speed motor should be employed.

BRIDGEPORT UPRIGHT SURFACE GRINDER

The machine shown in the accompanying illustrations is a recent product of the Bridgeport Safety Emery Wheel Co., Inc., Bridgeport, Conn., and is adapted for surface grinding operations on work that can be held by hand or laid on the grinding face of the wheel. The wheel is held in a Bridgeport chuck, the body of which is a solid steel casting that is made thicker near the front edge where most of the strain comes. The chuck is turned to a uniform taper on the inside and is provided with a number of plain independent jaws, the number depending upon the diameter of the chuck. These jaws are operated by a screw in the back end of the body casting, which moves them in or out as desired. A long hub on the inside of the body is splined on the spindle, and affords a long bearing surface to keep it in alignment. The outside of this hub is threaded so that a backing-up plate can be screwed onto it. This plate is screwed up against the back of the wheel as fast as the wheel is worn away, and provides a very satisfactory means of supporting the thrust of the work against the wheel.

The chuck is mounted on a steel spindle which runs in bearings of ample proportions. The upper bearing is made with a taper bronze bushing and lock-nuts to provide means of compensating for wear. The lower bearing is equipped with a radial and a thrust bearing. As the wheel wears away, it is raised to the proper height by releasing the chuck jaws and advancing the back plate on the threaded hub in the manner which has already been described. The spindle is locked during this operation by means of a pin or bolt on the side of the base, which slides into a hole

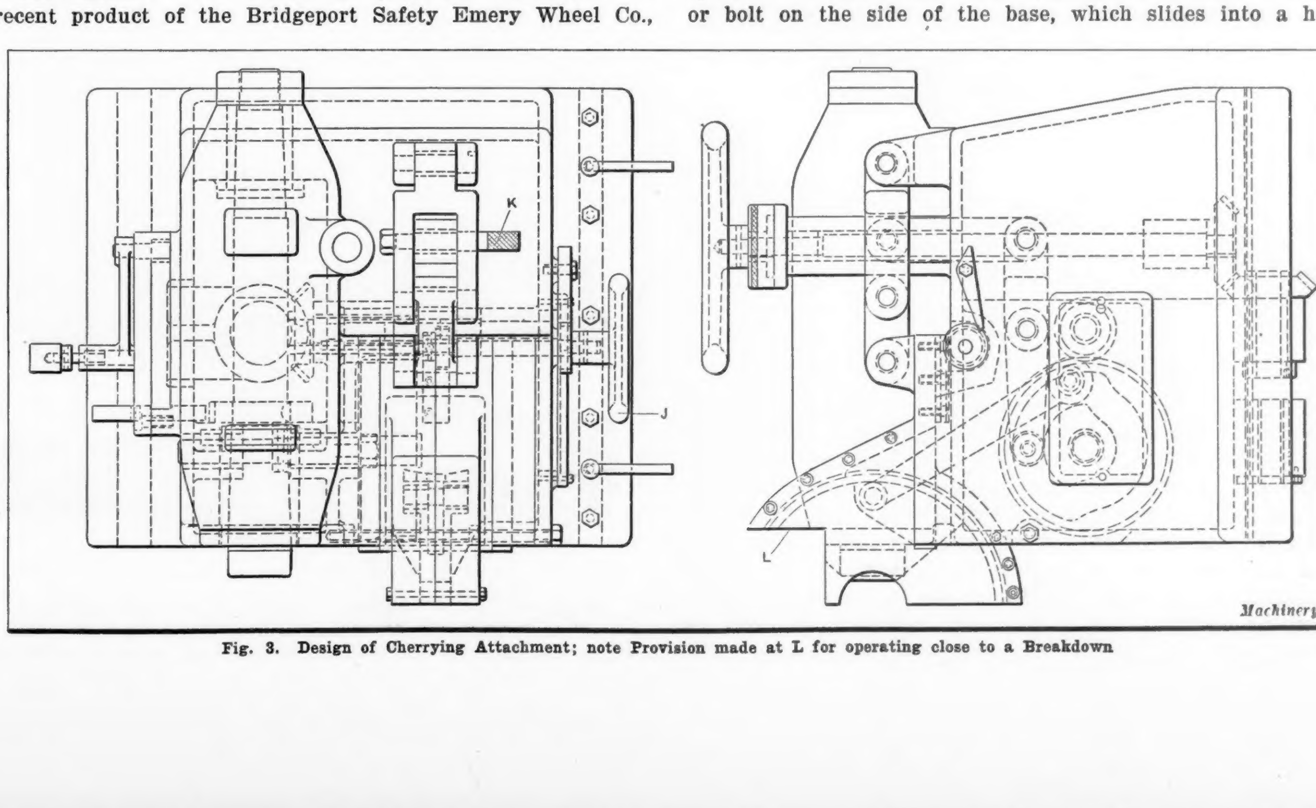


Fig. 3. Design of Cherrying Attachment; note Provision made at L for operating close to a Breakdown

Fig. 1. Bridgeport Upright Surface Grinding Machine

on the under side of the chuck.

There is a steel cross bar 1¼ by 3 inches in size, which is bolted across the top of the work-table. A slide rest is attached to this bar to provide for carrying the wheel truing device. This cross bar also forms a stop for large work placed on the wheel, so that the work can come up against it and be prevented from moving with the wheel. A large circular table surrounds the wheel, and the work can be set on this table preparatory to moving it over the wheel. The principal dimensions of the machine are as follows: height from floor to top of table, 37½ inches; size of grinding wheel, 30 inches diameter by 8 inches face width, with a hole 10 inches in diameter; diameter of work-table, 42½ inches; floor space occupied, 65 by 40 inches; and weight of machine, 3550 pounds.

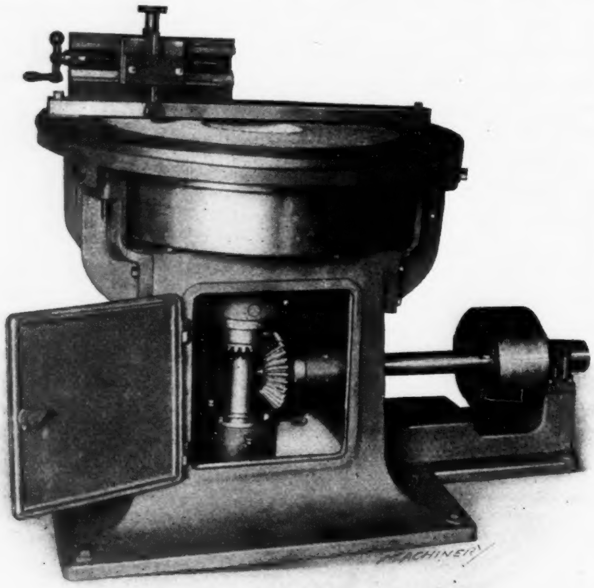


Fig. 2. Machine shown in Fig. 1 with Wheel Truing Device in Place on Cross Bar

RENO-KAETKER SWING SAW

The swing saw which is shown in the accompanying illustration is manufactured by the Reno-Kaetker Electric Co., 610-616 Baymiller St., Cincinnati, Ohio, and is known as the "Reliance" swing saw. The design of this machine has been worked out to meet the requirements of the packing rooms of manufacturing plants in which the product is being crated for shipment. It will be seen that the motor and saw are combined in a single unit which can be set up in any convenient position. As it is merely necessary to carry two power wires to the motor, it will be evident that the installation is a very simple matter. The whole outfit is held in place by four bolts.

The motor is equipped with an automatic starter, and is started and stopped by an ordinary knife switch. The frame is made up of a cast-iron base and a cast-iron arm. The saw is counterbalanced so that it swings back automatically when the handle is released. These saws are made in three different sizes to provide for cutting practically all thicknesses of lumber. The No. 201 saw is adapted for 10, 12-, or 14-inch saw blades; it is equipped with a 2-horsepower motor, and will cut lumber up to 2 inches in thickness. The No. 203 saw is adapted for saws from 16 to 24 inches in diameter; it is equipped with a 3- or 5-horsepower motor, depending on the kind of material to be cut, and is adapted for all work up to 5 and 6 inches in thickness. The No. 204 saw will take blades from 24 to 36 inches diameter; it has a 7½- or 10-horsepower motor, and is suitable for use in railroad shops or lumber mills where heavy work is done.

"Reliance" Swing Saw made by the Reno-Kaetker Electric Co.

ROGERS TAPER-END PLUG GAGES

The taper-end plug gages, which are illustrated and described herewith, are made by the John M. Rogers Works, Inc., Gloucester City, N. J. These gages are tapered at the end which enters the work, making it possible for the mechanic to quickly insert the gage into the hole and determine the amount of stock which still remains to be removed. In this way they serve the same purpose as the standard form of plug gage, and at the same time provide for determining the amount of stock which remains to be removed. Obviously they can be used far more rapidly than a caliper, and there is no chance for making a mistake in transferring sizes.

In addition to the advantages which have already been mentioned, the taper end of the Rogers plug gages makes it an easy matter to enter them into accurately finished holes. The gage marked *A* is intended for testing the size of work on which an accurate finishing operation is being performed. The end of this gage has a single taper. If, however, the gage is required for testing work on which

Rogers Plug Gages. Gage A is for Finished Work and Gage B for Work on which both Roughing and Finishing Cuts are to be taken

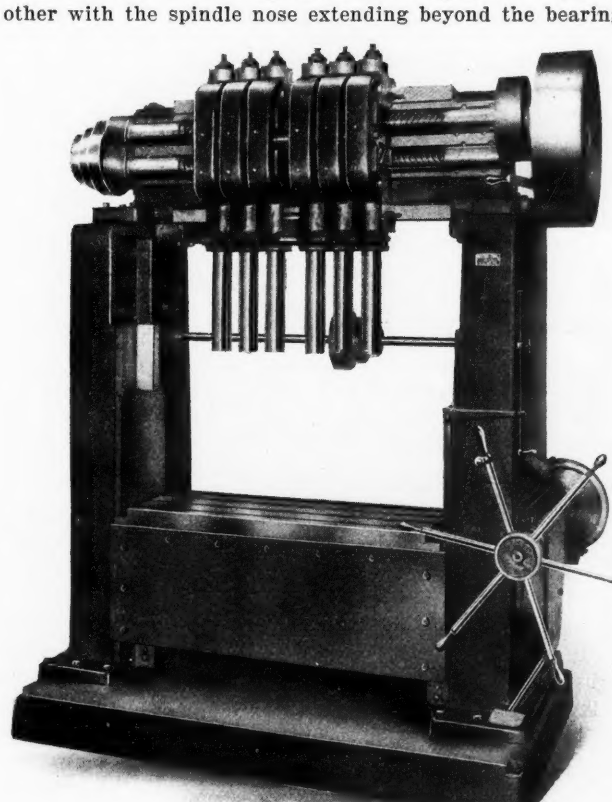
roughing cuts are being taken, as well as work on which finishing operations are being done, the gage employed is of the form shown at *B*. It will be seen that this gage has a double taper, the amount of each taper being altered to suit the requirements of different classes of work. The maximum and minimum sizes are marked on gage *A*; and gage *B* has these sizes indicated, in addition to the intermediate size which is marked "mez."—an abbreviation of mezzo or medium.

MOLINE CYLINDER BORING MACHINE

The machine which forms the subject of this article is a recent product of the Moline Tool Co., Moline, Ill. It is known as the No. 5-D cylinder borer and was designed to give a high rate of production on automobile cylinders—especially on the type where six cylinders are cast *en bloc*, with the crank-case an integral part of the cylinder block. When working on cylinders of this type with many types of machines, there is an excessive amount of overhang, but in the Moline No. 5-D cylinder borer this difficulty has been overcome.

The machine is made in one standard length with 4 feet between the knees; but it is built with different heights from the table to the spindles in order to accommodate different styles of cylinders. The knees have a bearing 42 inches in length and are provided with bronze tapered wedges to take up side wear. The feed is obtained by double 6-pitch racks which have a face width of 3 inches; these racks mesh with pinions cut in the 3½-inch feed shaft. Nine changes of feed are provided, ranging from approximately 1/64 to 3/16 inch per revolution of the spindle. The spindles are driven by 4-pitch bronze and steel spiral gears. The table is of box section; it is 18 inches wide by 4 feet long and about 18 inches deep.

Two types of heads are furnished on the machine, one with the sleeve extending down to the spindle nose, and the other with the spindle nose extending beyond the bearing, so



Moline No. 5-D Cylinder Boring Machine

that it can be guided in a bushing in the jig if so desired. Different sizes of heads can be furnished, ranging from a minimum adjustment of 3 inches up to any size that is required. The pilot wheel is located at the right-hand side where it will not interfere with setting up work on the machine and removing the finished cylinders. The drive is from a two-speed friction countershaft which carries pulleys 24 inches in diameter by 6 inches face width. A brake is provided on the main driving pulley to enable the machine to be stopped quickly. All thrust loads are carried by ball bearings, and all high-speed bearings are bronze bushed, while the low-speed bearings are bushed with cast iron.

CURTIS PIPE AND BOLT THREADING MACHINE

A recent addition to the line of pipe machines made by the Curtis & Curtis Co., 8 Garden St., Bridgeport, Conn., consists of a bed-type of machine which is illustrated and

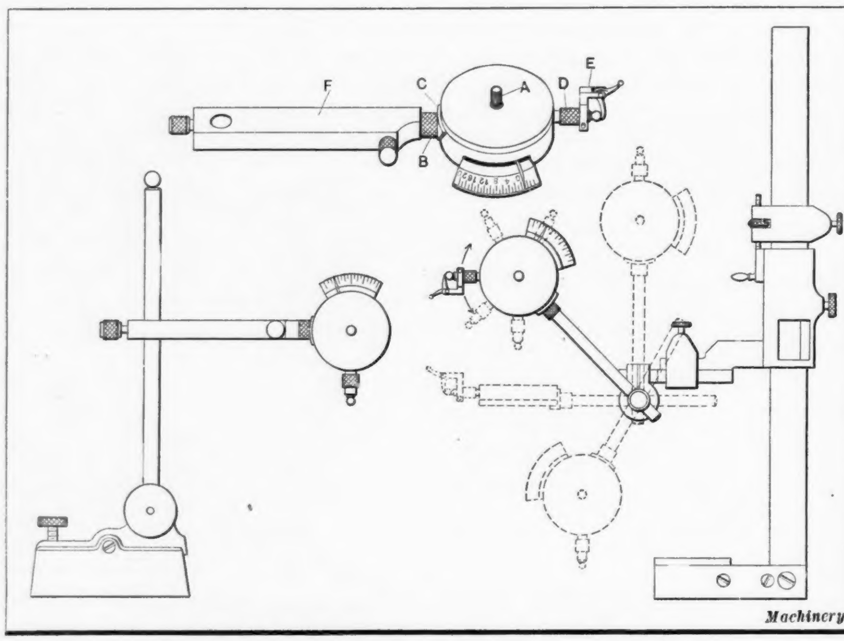
Curtis Pipe and Bolt Threading Machine

described herewith. In operating this machine, the work is clamped in the vise by hand, and the feed of the work to the die head is also hand operated. After the threading operation has been completed, the die head is opened; and in cases where the machine is working from bar stock or a long piece of pipe, the work is then moved on through the die head into such a position that the cut-off attachment can be employed to cut off a piece of the required length.

The die head employed on this machine is of the well-known type which has been used on Curtis & Curtis pipe-threading machines for a number of years. The head is graduated so that it can be set for threading pipe or bolts of any diameter; and after this preliminary setting has been made, the dies are clamped in the required position. A stop is then set for this position. Then in the operation of the machine it is merely necessary to close in the dies until the stop is engaged, after which the die head is clamped in position for the threading operation. After the thread has been cut, the clamp is released to provide for opening the dies. The benefit of this arrangement is that it enables the die head to be set much more rapidly than could be done if it were necessary to refer to a graduated collar every time the dies were opened. Furthermore, the setting may be made rapidly in a place where the light is very poor.

FUCHS UNIVERSAL TEST INDICATOR

In the universal test indicator which has recently been placed on the market by the Leon Fuchs Mfg. Co., P. O. Box 216, Dayton, Ohio, the following are features which are of importance to the user: Accuracy, high magnifying power, extreme sensitiveness, and universal adjustability, combined



Fuchs Universal Test Indicator and Two Methods of mounting it

in a simple instrument which is constructed to withstand hard usage. There are no intricate parts to get out of order or delicate parts which are likely to be broken. The indicator is applicable for measuring either flat or curved work, and can be employed for making internal or external measurements. The contact feeler for both internal and external use may be adjusted to any radial position throughout an entire circle without changing the position of the indicator, making it easy to read. It is accurate in all positions.

To adjust the contact feeler, the knurled stud *A* is loosened and the head rotated to the desired position. The stud *A* is then tightened to secure the feeler in the required position. In order to vary the tension of the rotatable head, the friction shoe *C* is adjusted by means of the knurled nut *B*. The internal feeler *E* may be slipped off the stem *D*, or it may be rotated to different positions, as desired. The holder *F* is used in securing the instrument in the toolpost of a machine. When the indicator is to be used on a stand of a surface gage, height gage, or other tool of this character, the holder *F* is removed. The readings of the instrument are in 0.001 inch, and the range is 0.024 inch. The pointer is provided with an automatic take-up which eliminates undue vibration and lost motion. All bearings and contacts are made of hardened steel, and the instrument responds quickly to any variation in the work. A plush-lined case can be supplied for the indicator, although this is not regularly provided.

BROWN & SHARPE SPIRAL MILLING ATTACHMENT

A recent addition to the line of milling attachments manufactured by the Brown & Sharpe Mfg. Co., Providence, R. I., is a spiral milling attachment designed for handling heavy classes of spiral cutting. This attachment, which is used in combination with a spiral head, is made in four sizes, making it adaptable to practically the entire line of plain and universal milling machines manufactured by this company. Fig. 1 shows the attachment in place on the machine. It will be noted that the method of clamping to the overhanging arm as well as to the face of the column insures rigidity, and makes the attachment practically a part of the machine.

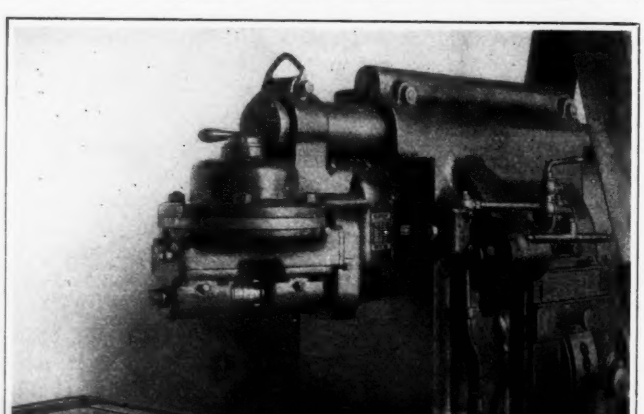


Fig. 1. Brown & Sharpe Heavy Spiral Cutting Attachment for Milling Machine; note Method of clamping to both Face of Column and Over-arm

To facilitate handling, provision is made for fastening a hook at the top of the attachment. The spindle is hardened, ground, and runs in phosphor-bronze boxes having means of compensation for wear. It is driven from the machine spindle by hardened steel spur and bevel gears, as shown by the vertical section, Fig. 2; and can be set at any angle in a horizontal plane, the position being indicated by graduations reading to one-half degree.

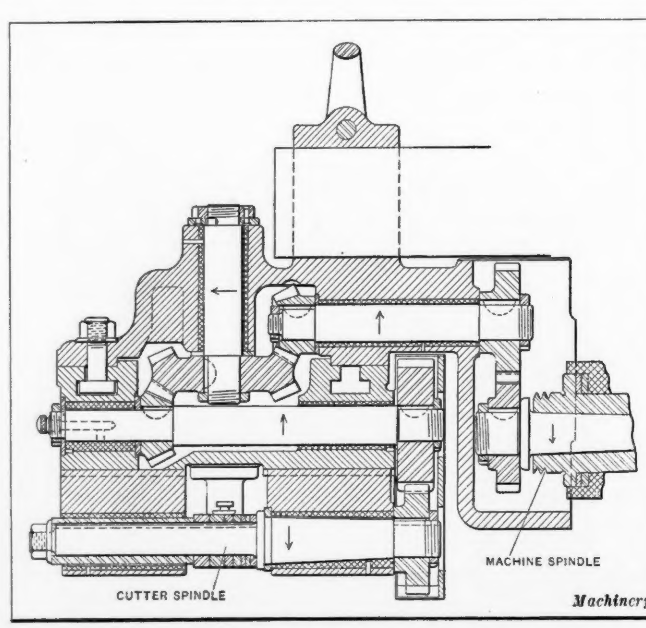


Fig. 2. Vertical Cross-sectional View of Attachment, showing how Drive is taken from Machine Spindle

To insure rigidity and to enable heavy cuts to be taken, the cutter spindle is provided with an outer bearing which can be easily removed when placing a cutter in position. The inner spindle bearing is adjustable, the adjustment being made by a screw having a graduated dial on the front end of the attachment which reads to 0.001 inch. This adjustment is valuable when setting the cutter central with the swiveling point or when off-setting the cutter any definite amount. A suitable gage is provided to enable the cutter to be set central with the swiveling point. This gage slides in V-ways on the attachment, a thumb-screw clamping the gage at any desired distance from the cutter spindle. The regular machine spindle speed change mechanism is used to obtain the different cutter speeds. All gears and wearing surfaces are enclosed, preventing injury from dust and dirt, as well as giving a neat and compact appearance, as will be seen from the illustration.

PERSONS-ARTER "MODEL A" ROTARY SURFACE GRINDER

The following are features of this machine which add to its efficiency of operation. The wheel-slide is provided with a reversing mechanism which enables it to work on an exceptionally short stroke, the range being for strokes from ½ inch up. To provide for truing the wheel, the drive for the chuck spindle and wheel-slide are independent so that the truing device may be mounted on the chuck and have the wheel reciprocated across it. The belt tension is maintained by a compensating idler which absorbs all shocks and gives an unusually smooth drive. All parts of the machine are made exceptionally heavy so that the maximum rigidity is obtained.

The rotary surface grinder shown in the illustrations presented herewith is the product of the Persons-Arter Machine Co., Worcester, Mass., and is one of a line of grinding machines that this company is putting on the market. This machine is intended for the rapid and accurate grinding of such work as the ends of bearing races, thrust washers, piston rings, etc. The "Model A" machine has a capacity for handling work up to 8 inches in diameter. It is believed that 90 per cent of the commercial rotary surface grinding done comes under 8 inches in diameter and for that reason an 8-inch machine was designed. Although the nominal capacity in diameter is 8 inches, the machine has a swing clear of the front edge of the wheel of 10¾ inches, allowing of grinding work which projects beyond the circumference of the chuck. A 10-inch chuck can therefore be used on the machine if required. As the vertical travel of the table is 11¼ inches, with a 12-inch wheel on the spindle, the highest piece of work that can be ground with a full size wheel is 11 inches, while work up to 13 inches deep can be ground by using a smaller wheel.

From Fig. 1 which shows the front view of the machine and Fig. 2 which shows the machine from the rear, it will be seen that the design is especially heavy. The base casting weighs 985 pounds; and the head is proportionately heavy. By following these heavy construction lines throughout, maximum rigidity for the machine is secured, which assists in eliminating vibration when grinding.

Fig. 3 shows the machine in front, rear and side elevation. In the end elevation the relation between the sliding head and the base of the machine is readily apparent. The distance between the centers of the ways is 10 inches and one way is of V-type while the other is flat—thus insuring a true movement of the head. The head and base have a sliding contact of 27 inches and even when working at maximum diameter, the

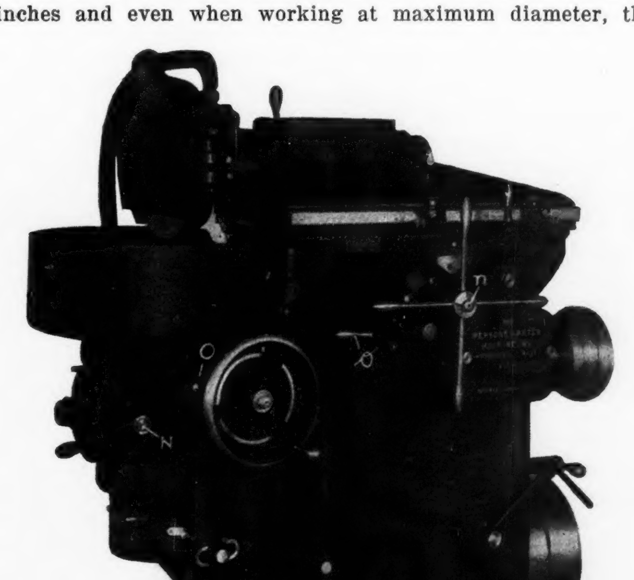


Fig. 1. Persons-Arter "Model A" Rotary Surface Grinder

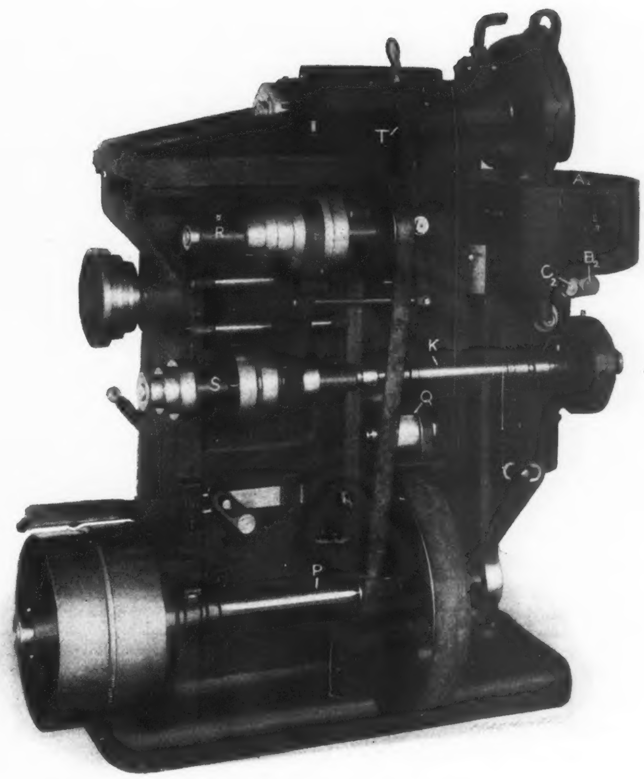


Fig. 2. Opposite Side of Machine shown in Fig. 1

ways are not uncovered for a length of more than 1 inch. Dust and grit are effectively kept from both slides by a canvas protection, attached at one end to the front of the head and at the other end to the top of the chuck spindle slide.

The Spindle and Its Bearings

The wheel spindle is shown in detail in Fig. 4. It is mounted as low on the sliding head as is practicable, and is 2 3/16 inches diameter, made of chrome-nickel steel, heat-treated, and runs in bronze bearings 4½ inches long and located 16½ inches from center to center. These bearings are of the split tapered type, thus providing for take-up in case of wear. The spindle and its bearings are protected from dust for the full length and yet are readily accessible by the removal of a plate from the top of the slide. Attention is called to the precautions taken for keeping dust from the spindle bearings. At the head end of the spindle the front face of the bearing cap is channelled out to allow a projection *A* on the spindle nose to pass it. This spindle nose projection has a groove *B* to pocket any dust or grit before it can pass the "lock." A second safeguard is a groove *C* on the spindle beyond the lock and should any dust pass this point, a deep internal groove *D* in the bearing cap forms another and third obstruction. The grinding wheel is entirely enclosed but can be exposed by loosening a thumb-nut at the front and removing the wheel cover plate.

Referring now to the opposite end of this illustration, Fig. 4, the method of controlling the end thrust of the spindle may be seen. A hardened and ground bearing flange *E* is bolted to this end of the spindle and a bronze nut *F* on the outer end locates the flange against a bronze seat on the end of the slide. The spindle bearings are oiled directly through oil holes leading to the top of the slide.

The Chuck Spindle Mechanism

Fig. 5 shows the chuck spindle and its operating mechanism in section. The chuck spindle slide runs in broad bearings and the adjusting gib is made "fool-proof" by being tapered from end to end, and therefore, for adjusting requires only the turning of a screw at the top that advances or withdraws the gib—automatically changing the adjustment equally at all points of the slide. The slide is raised or lowered by the handwheel shown in front of the machine in Fig. 1. This handwheel turns a short shaft on which is a bevel gear that meshes with the bevel gear *G* that may be seen on the elevating screw *H* in Fig. 5. The thrust is taken against a ball

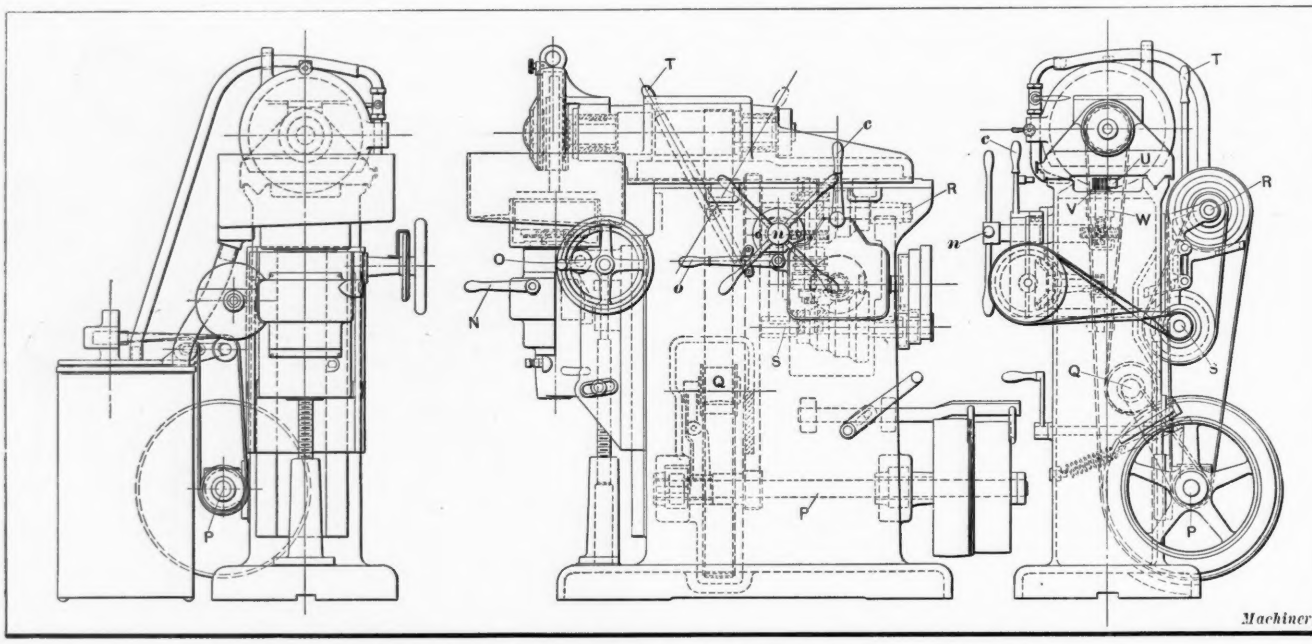


Fig. 3. Front, Rear and Side Views of Persons-Arter "Model A" Rotary Surface Grinder

bearing *I*. The chuck spindle, as shown in Fig. 5, is guided at the top by a bearing of tapered type, having a bearing angle of 65 degrees from the horizontal. The lower bearing, 12 inches below, is made of cast iron, as its only work is to steady the spindle. The top bearing receives the spindle thrust by means of a hardened and ground tapered collar *J*. Lubrication is by means of a spiral oil groove in the bearing collar that carries the oil up to the top of the collar; it then flows back down the bearing by means of a straight groove. The bearing is thus lubricated by the oil going up as well as coming back.

From Fig. 2 an idea of the way the chuck spindle drive is secured may be obtained. At the front end of the machine may be seen the driving shaft *K* for the chuck spindle. This terminates in a spiral gear of bronze that meshes with a cast-iron spiral gear *L* running loose on the chuck spindle, as shown in Fig. 5. Midway on the spindle is a clutch collar *M* slidably keyed to the spindle, and when the clutch lever *N* is thrown, teeth on the lower face of the clutch collar engage teeth on the upper face of the gear, and the gear is thus made to rotate the spindle. This permits the chuck spindle to be stopped independently of the wheel-slide traverse; this is one of the important features of the machine. One of the advantages in being able to stop the chuck spindle independently is in truing the wheel, when, of course, it is desirable to stop rotation of the chuck spindle and still have an automatic traverse to the slide carrying the wheel spindle.

The entire chuck spindle and its mechanism is pivoted at pin *O* on the slide so that any degree of concave or convex surface may be obtained within a range of 5 degrees in either direction from the center. Finished bosses are left on the main casting of the machine near the chuck slide, so that a vertical feeding mechanism may be applied if desired. The wheel spindle slide drive and the chuck spindle drive are from the same shaft, being thereby interlocked so that the same relative feeds between the chuck spindle and the wheel spindle slide drive are maintained, being proportionate to the number of revolutions of the chuck.

The Wheel Spindle Drive

Having now taken up in detail the construction of the wheel and chuck spindles and their slides, it will be in order to describe the mechanism for driving the spindle. This can best be studied from Figs. 2 and 3 that show the rear side of the machine. The main drive shaft *P* may be seen low down upon the machine, and rotation is received over a tight and loose pulley at the left-hand end. An extremely large diameter pulley on the opposite end of this shaft transmits the drive directly to the wheel spindle of the machine. The arrangement of this drive may best be seen in Fig. 3, which shows the machine in end elevation. A feature of this drive is the application of a flexible idler pulley *Q*, whose function it is to keep the belt under the proper driving tension all the time, and to receive all shock or strain that might be transmitted to the spindle from the inaccuracy of the belt drive. As shown in Fig. 3, this idler is spring-controlled and the arm upon which it is mounted is free to change its position under any pressure. The machine is stopped or started by throwing the belt from the loose pulley to the tight pulley, or *vice versa* by means of a hand lever that is best shown in Fig. 1 at the front of the machine. This lever operates a shifter bar that acts directly on the belt. The main drive is transmitted through a 3½-inch belt, while the wheel spindle is driven by a 3-inch belt, thus supplying ample power for taking heavy "hogging" cuts.

From the driving shaft, rotation is carried to an intermediate shaft *R*, plainly shown in Fig. 2, and on this shaft is a four-step cone pulley that carries rotation to the chuck spindle operating shaft *S* below. On this shaft there is a corresponding four-step cone pulley, and a hand lever *T* operating the belt connecting the two pulleys gives, at a moment's notice, any of four different rates of feed. It should be

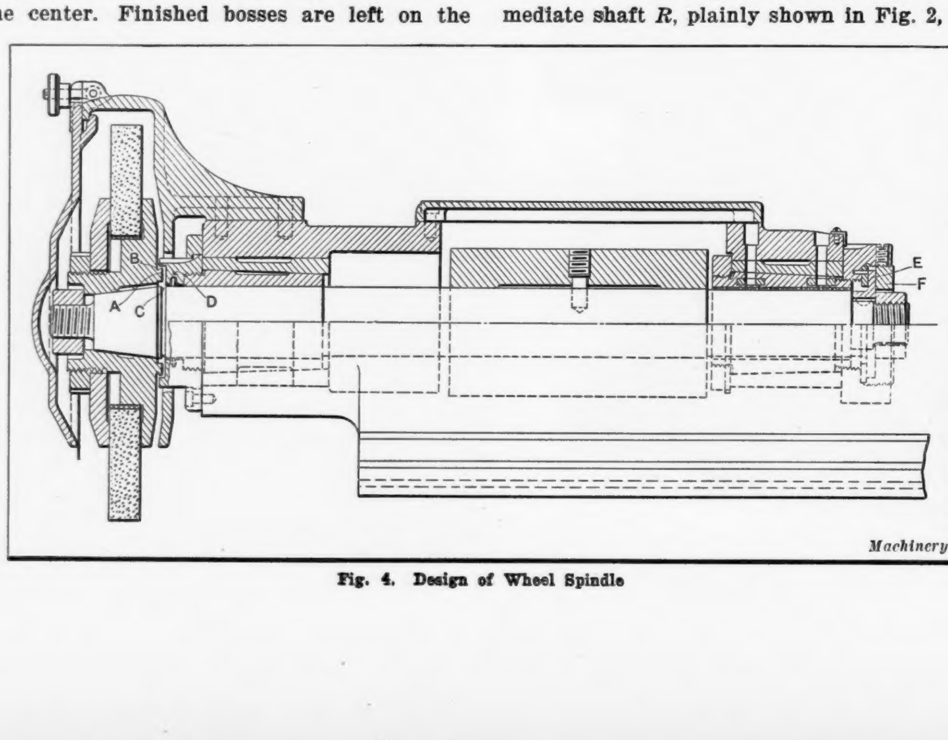


Fig. 4. Design of Wheel Spindle

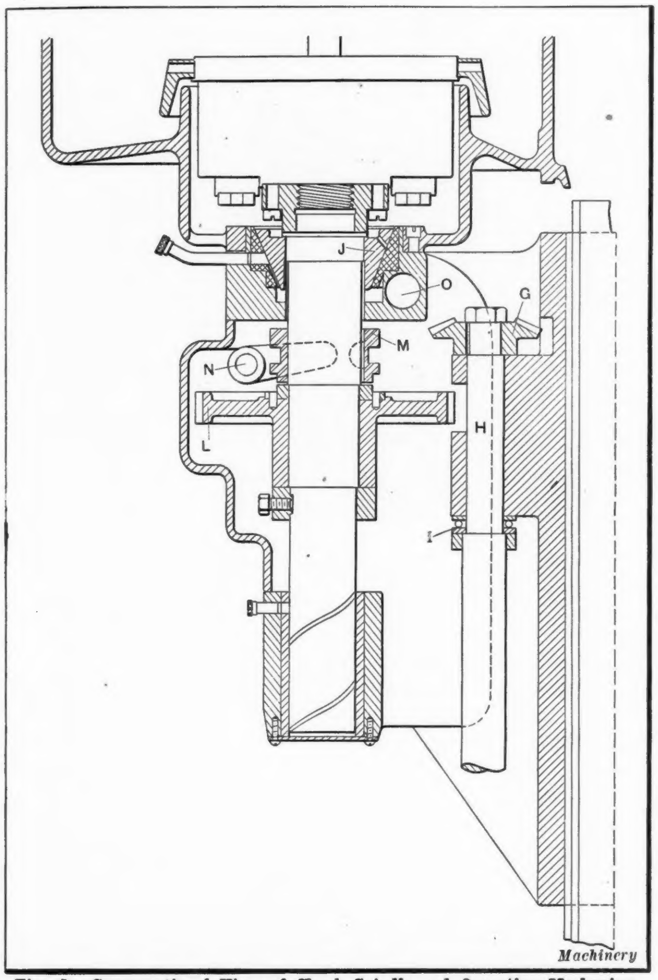


Fig. 5. Cross-sectional View of Chuck Spindle and Operating Mechanism

noticed that the column of the machine is relieved to allow this chuck spindle operating shaft S to lie in the same vertical plane as the axis of the spiral gear at the opposite end of the shaft. This operating shaft is connected with the chuck spindle drive-shaft K by flexible joints, but as it is in the same vertical plane, any raising or lowering of the chuck slide simply causes the shaft to be operated at an angle varying in one plane only. From the left-hand end of this shaft the drive is carried to the slide traversing mechanism at the front of the machine. This is done through the medium of three-step cone pulleys so that a combination of twelve different feeds may be given to the wheel-slide traversing mechanism.

The Wheel-slide Reversing Clutch

By turning now to Fig. 6, which shows the slide controlling mechanism with the cover plate removed, one of the strongest features of the machine may be seen. As was mentioned in connection with Fig. 2, rotation is carried to this mechanism from the three-cone pulley on the end of the chuck spindle driving shaft S. As may be seen in the extreme right-hand section of Fig. 3, the wheel-slide is traversed by a rack U and a pinion V. This pinion is located on a vertical shaft W that is driven by worm-gearing extending through the machine, and terminates at the front of the machine in the large bevel gear X that may be seen in Fig. 6. This bevel gear and the horizontal shaft to which it is keyed may be driven in one direction or the other by means of two bevel pinions Y and Z, both of which are always in mesh with the gear X. When one of these is driving the bevel gear, the other is running idle. A double faced clutch a that may be seen in the center, is slidably keyed to the shaft b and engages the clutch teeth on the inner faces of the bevel pinion Y or Z according to the direction in which the wheel-slide is being traversed. The method of shifting this clutch is by means of the central lever c that is actuated by dogs d upon the wheel-slide. This lever is fulcrumed near its center at f, and at its lower end is a pin g whose function it is to throw up either of two latches h or i that alternately catch the ends of the clutch bearing. The clutch is thus thrown from one direction to the other, under pressure of the spiral spring j.

The operation of this mechanism is as follows: When the lever c is thrown to one extreme by contact with one of the stop dogs or by hand, it causes one of the latches h or i to be raised and the clutch collar a flies over, and consequently the shaft and clutch collar are directly geared to one of the bevel pinions Y or Z, and the table is then traversed. When the opposite dog is reached, the lever is again thrown over, causing pin g to raise the other latch, and the clutch flies in the opposite direction under the action of the spring, the table travel again being reversed. The fact that the clutch sleeve is operated by a single spring is the principal feature of this mechanism. It avoids a difficulty which has heretofore been experienced with similar mechanisms in which independent springs have been used to throw the clutch part in opposite directions, and in which it was found that the reversing mechanism often failed to work owing to the fact that these springs worked in opposition to each other or that one spring was stronger than the other.

The action of this single spring reversing mechanism is so positive that even as short a distance as one-half inch may be traversed without difficulty. This is especially valuable when grinding work like piston rings on which a further traverse would be a waste of time. Another feature is the design of the dogs that limit the travel of the wheel-slide. These operate in connection with an inverted rack on the side of the wheel-slide. By depressing spring knobs k at the top, they are released from contact with the rack and can be moved to any position. Releasing pressure on the knob causes a toothed lock to snap back in place and hold the dog stationary. For securing limitations of travel more exacting than one tooth of the rack, a small adjusting screw l on the dog is turned, allowing the trip m to swing back slightly or advance to get any desired reversing point.

In addition to the power traverse of the wheel-slide, there is a hand traversing wheel n, Fig. 1, and during the operation by hand, the power traversing mechanism must be thrown out by means of a clutch lever o, shown just beneath the hand traversing wheel, that operates a clutch on the vertical shaft within the column of the machine. It may here be mentioned that in cases where the operator must stand in front of the machine for facilitating rapid production, a treadle lever may be used in place of the hand lever o for operating the power feed clutch, and provision has been made for the

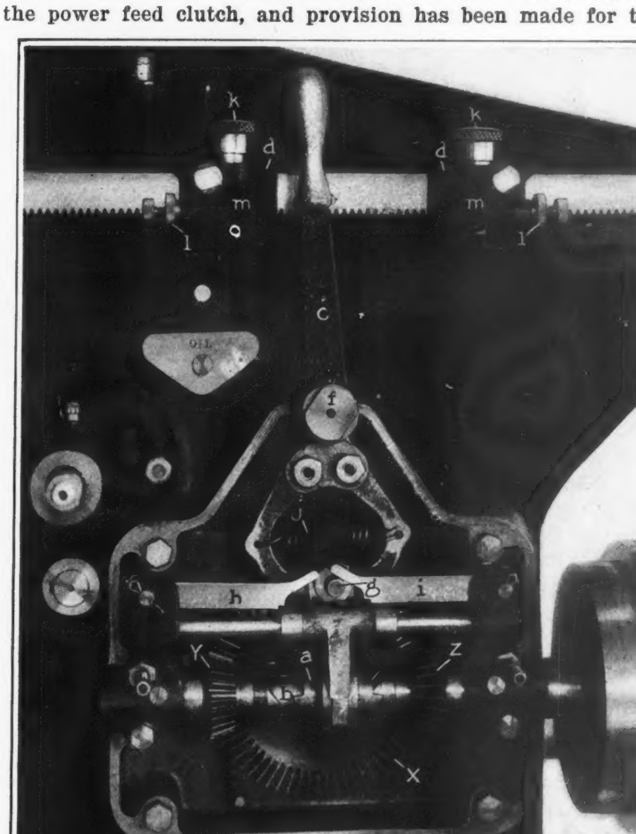


Fig. 6. Slide Controlling Mechanism with Cover Plate removed

application of this particular feature. Also located on this vertical shaft is a friction, so that if for any reason the wheel-slide is advanced far enough to run into the water guard, the pressure between the front of the slide and the water guard will cause the friction to slip and no damage will be done.

Special attention has been given to the design of the water pan for carrying away the water used for cooling, and also with respect to the protection of the chuck and its electrical connections, and convenience in their examination or removal. All wiring is contained in the water pan, A_2, Fig. 2, and the magnetizing of the chuck is performed by means of an extra heavy, double pole switch which has a quick-action demagnetizing feature. The wiring is protected by means of a fuse B_2, which is placed on the same base as the plug socket C_2. The brushes are so arranged that they can readily be examined from underneath the water pan, and if found necessary, they may be removed without disturbing any other part of the machine. The bottom of this pan slopes in both directions to carry the water quickly down to one corner, where the outlet is located. The approach to the outlet is cored away so as to break up any tendency of the water to "eddy." The water tank is of large capacity and is placed conveniently beside the machine. The water pump is of sufficient size to carry as heavy a stream of water as is necessary for any grinding. Except for the water tank, the machine is self-contained in every way, making it ready for immediate use by simply belting from the lineshafting to the drive-shaft.

NEIL & SMITH HEAVY-DUTY GRINDER

The most noteworthy feature of the "Ideal" heavy-duty grinders manufactured by the Neil & Smith Electric Tool Co., Cincinnati, Ohio, is the provision of means for varying the speed so that the operator is able to maintain the correct peripheral speed of the grinding wheel as it wears down, or to vary the speed of the wheel until it reaches the number of surface feet per minute that is most effective for the class

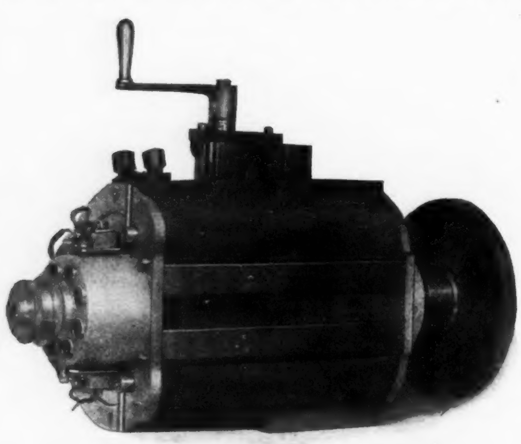


Fig. 1. Neil & Smith "Ideal" Heavy-duty Grinder

of work that is being done. The means for regulating the speed is such that the speed can be stepped off a revolution at a time, if such a fine adjustment is necessary; and the change of speed can be made while the grinder is in operation. The control is obtained through a mechanical device embodied in the construction of the grinder and is not dependent upon the rheostat.

In designing this grinder particular attention has been paid to the problem of reducing overhang as far as possible. With this object in view the motor housing has been designed to bring the wheel spindle as near to the operating side as possible. Thus in the largest size of this line of grinders, which is driven by a three-horsepower motor, the distance from the spindle to the face of the housing is only 2⅞ inches. Exceptionally small diameter wheels can also be employed, and these two features are the means of obtaining exceptional rigidity.

The spindles are made of tool steel hardened and ground, and carried by bronze bearings provided with means of adjusting for wear. In addition, a ball bearing is provided to carry the weight of the armature when the grinder is used

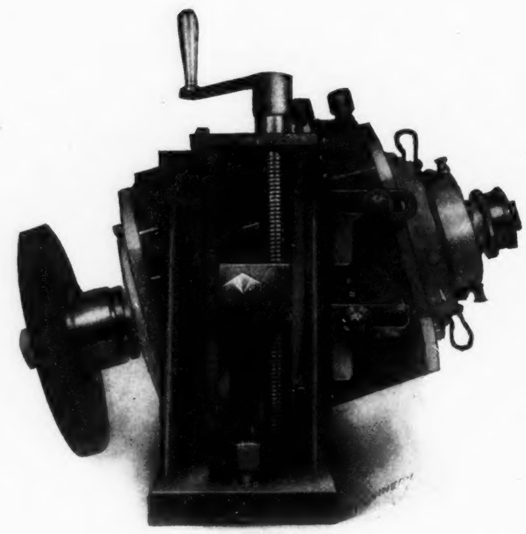


Fig. 2. Opposite Side of Neil & Smith Grinder shown in Fig. 1

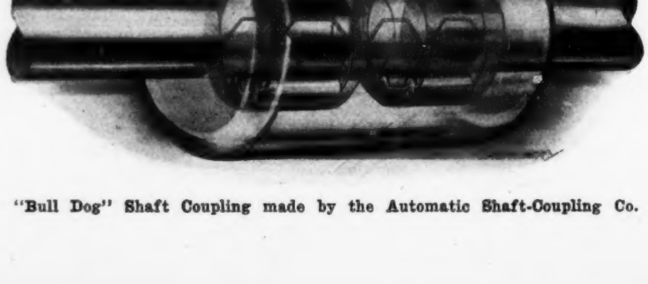
in a vertical position. The bronze bushing is tapered on the outside and split through one side; it is loosely mounted in a collar that screws on the outside of the rear head of the motor. The bushing and collar being a single unit, adjustment of the bearing can be made by simply tightening or loosening the collar. These grinders are made in four different sizes which are driven by one-quarter, three-quarter, one and one-half, and three-horsepower motors, respectively.

AUTOMATIC SHAFT COUPLING

In the "Bull Dog" shaft coupling which is made by the Automatic Shaft-Coupling Co., Alexandria, Va., and for which the Campbell Machinery Co., 5-7 Beekman St., New York City, has the exclusive sales agency, the clamping action is secured by hardened steel rollers which are carried in eccentric chambers in the body of the coupling. Three of the most important features of this coupling are that it can be applied by hand without requiring the use of any tools; that it is unnecessary to cut any keyways in the shaft; and that there are no projecting set-screws or other parts which can catch in the workman's clothes and cause injury.

The coupling provides for holding the shafting in perfect alignment, and when a suitable reducing coupling is employed, shafts of different diameters may be connected. The coupling is of simple construction, consisting merely of a metal cylinder with the eccentric chambers in which the clamping rollers are carried. There are no wearing parts and hence the expense of renewals is practically eliminated. It is never necessary to make adjustments of the coupling, and oil or dampness cannot affect it. In addition to the regular purpose for which it is intended, another use of this coupling is in making emergency repairs on broken shafts. The coupling can be slipped over the fracture and tightened, making it possible to put the shaft into commission in a short time.

In applying the coupling, the first step is to remove all burrs on the shafting, after which the ends are slightly chamfered with a file. The chambers and bore of the coupling, as well as the ends and shafting which enter it, must be thoroughly cleaned, after which the rollers are put in place and the coupling is slipped onto the shaft. The rollers and bore of the coupling, and also the ends of the shafts, are



"Bull Dog" Shaft Coupling made by the Automatic Shaft-Coupling Co.

Fig. 2. "Bull Dog" Split Pulley Bushing

oiled with a heavy oil; and care is taken to have the ends of the shafts directly under the pin hole in the center of the coupling. When the pin hole is at the top of the coupling, the rollers are in the deepest part of the eccentric chambers and the coupling is loose on the shafts. After the coupling has been put on in this way, it is merely necessary to turn on the power and the resistance binds the rollers in the eccentric chambers and locks the shafts firmly in place.

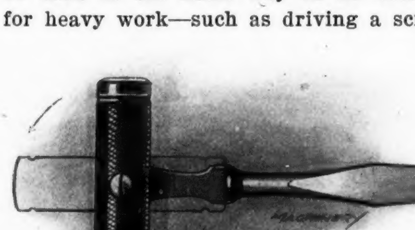
To remove the coupling, the driven pulley is turned forward, while the driving pulley remains stationary. This is done by putting a lever through the spokes and giving a quick jerk, which results in loosening the binding rollers on the driven side of the coupling. A pin or small bar is then put in the pin hole in the top, and struck with a hammer in the opposite direction, and this loosens the coupling.

These couplings are made in nineteen stock sizes with capacities for coupling shafts ranging from 1 3/16 to 8 inches in diameter. Smaller or larger sizes are made to special order. Reducing couplings for connecting two different sizes of shafts are also made; and the same clamping device is employed in set collars which are manufactured in fifteen stock sizes ranging from 1 3/16 to 6 inches in diameter. Special sizes are also made to order.

Still another application of this clamping device is in the "Bull Dog" split pulley bushing shown in Fig. 2. This is intended for use in connection with split pulleys, and it may be just as easily applied as an ordinary bushing. When the pulley is bolted together, the bushing does not bind on the shaft; it is just free enough to allow the pulley to be moved to the required position. The same arrangement of an eccentric chamber and clamping roller is provided in the bushing, and when the pulley has been set in the required position a slight turn binds it securely on the shaft. The strain of the drive keeps the pulley locked tight, but if it is desired to release the clamp, it is merely necessary to put a bar through the spokes of the pulley and give a sharp pull in the opposite direction to that in which the shaft runs. An important feature of "Bull Dog" shaft couplings, set collars and pulley bushings is the time saved in installation.

CRESCENT HAMMER-HANDLE SCREW-DRIVER

The accompanying illustration shows a combination hammer and screw-driver which has been placed on the market by the Crescent Tool Co., Jamestown, N. Y. This tool can be used in the same way as an ordinary screw-driver, but for heavy work—such as driving a screw into hard wood or starting a screw that has become rusted—the handle may be turned down at right angles to the blade to afford additional leverage. In this position, the tool gives very satisfactory service as a light hammer and will be found convenient for starting to drive wood screws. A strong spring holds the handle in place.

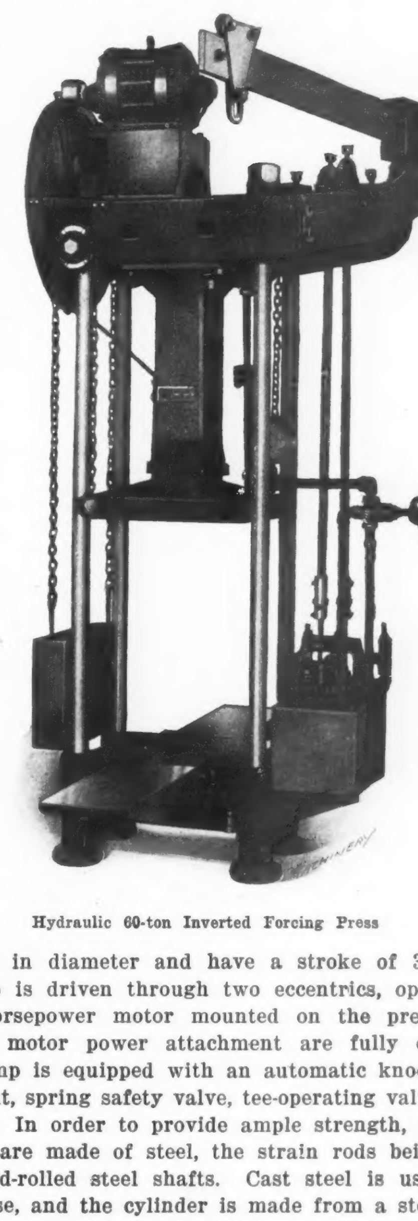


Crescent Hammer-handle Screw-driver

The blade of the screw-driver is of drop-forged steel, hardened and tempered in oil. The handle is knurled to afford a good grip, and the entire tool is nickel plated. The length of the blade is 6 inches, over-all length 10 inches, thickness of point 5/64 inch, and weight 14 ounces.

HYDRAULIC INVERTED FORCING PRESS

The accompanying illustration shows an inverted hydraulic forcing press which is a recent addition to the line of the Hydraulic Press Mfg. Co., 84 Lincoln Ave., Mount Gilead, Ohio. The press is a self-contained unit which requires no auxiliary water or power supply. It is usually equipped with electric motor drive, but belt drive may be applied when so desired. It will be seen that the press is of the inverted type in which the base or platen is located close to the floor, so that heavy work can easily be put in place. Detachable extension shelves, 12 inches wide by 30 inches long, are joined to each side of the press, and the work can be lifted onto either of these shelves by means of the hoist which is suspended from the swinging crane and trolley device on the head of the press. In this way the setting up of the heaviest work for which the press is adapted is quite a simple matter.



Hydraulic 60-ton Inverted Forcing Press

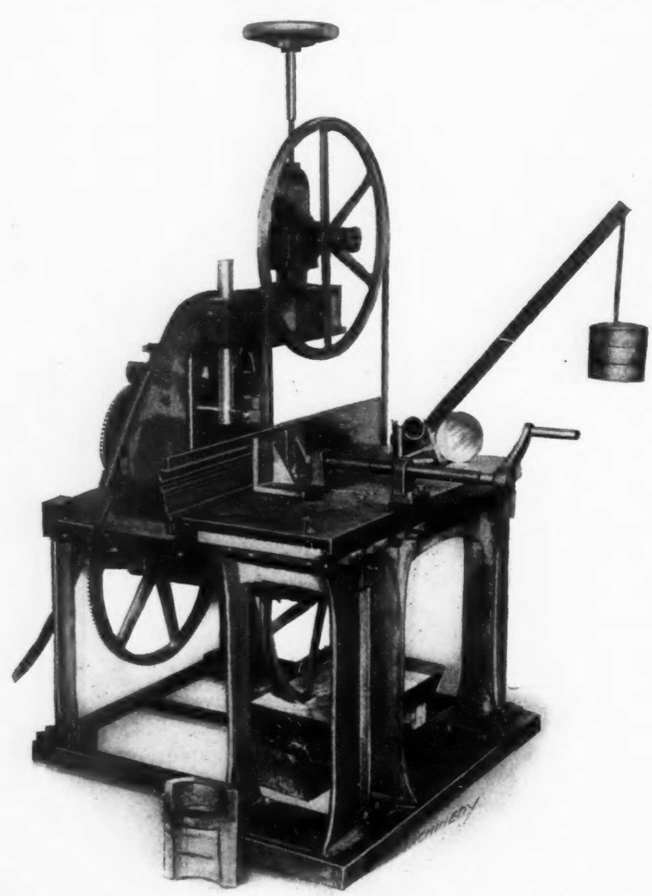
The press shown in the accompanying illustration is equipped with a two-plunger vertical hydraulic pump, the plungers of which are 5/8 inch in diameter and have a stroke of 3 1/2 inches. This pump is driven through two eccentrics, operated by a three-horsepower motor mounted on the press. The gears of the motor power attachment are fully enclosed, and the pump is equipped with an automatic knock-out valve attachment, spring safety valve, tee-operating valve, and pressure gage. In order to provide ample strength, all parts of the press are made of steel, the strain rods being made of bright cold-rolled steel shafts. Cast steel is used for the pressure base, and the cylinder is made from a steel casting. The lower platen of the press has a working surface of 24 by 22 inches, and there is a 6-inch hole in the center of the platen to provide clearance for the end of a hub or shaft during the pressing operation. The movable platen is 24 by 22 inches in size and is guided by babbitted bearings on the strain rods. The ram is returned by a weight after the pressing operation has been completed. The capacity of the press is for pressures up to 60 tons.

WILLIAMSON METAL-CUTTING BAND SAW

In the latest type of metal-cutting band saw which has been placed on the market by H. C. Williamson, 1840 W. Lake St., Chicago, Ill., capacity is provided for cutting work

ranging in size from 1/8 to 8 inches in diameter. An idea of the diversity of the material which can be cut on this machine will be gathered from the fact that it is being employed for cutting 8-inch I-beams, 8-inch square billets, and a great variety of sections of various sizes which come between these extremes. It is claimed for the machine that it will cut very accurate disks from tool steel bars, and that tubing and other light materials can be cut in an efficient manner. When handling certain classes of work, the back of the machine can be removed to give a flat table. The table is held stationary, and the feed is provided by moving the blade to the work rather than by feeding the heavy work up to the blade. This is the means of effecting a saving in the amount of power required to drive the machine. The frame that carries the wheels over which the saw runs and the driving mechanism, slides on ways on the machine; and provision is made for obtaining the feed either by hand or gravity. The saw guide is conveniently located and may be easily adjusted.

The pressure of the cut may be varied by changing the number of weights hung on the gravity feed lever. When the machine is equipped with individual motor drive, the motor may be mounted on the frame, as shown in the accompanying illustration. The tightening of the saw blade is accomplished by means of the handwheel shown at the top of the machine. It will be evident from the illustration that the design has been worked out along very simple lines,

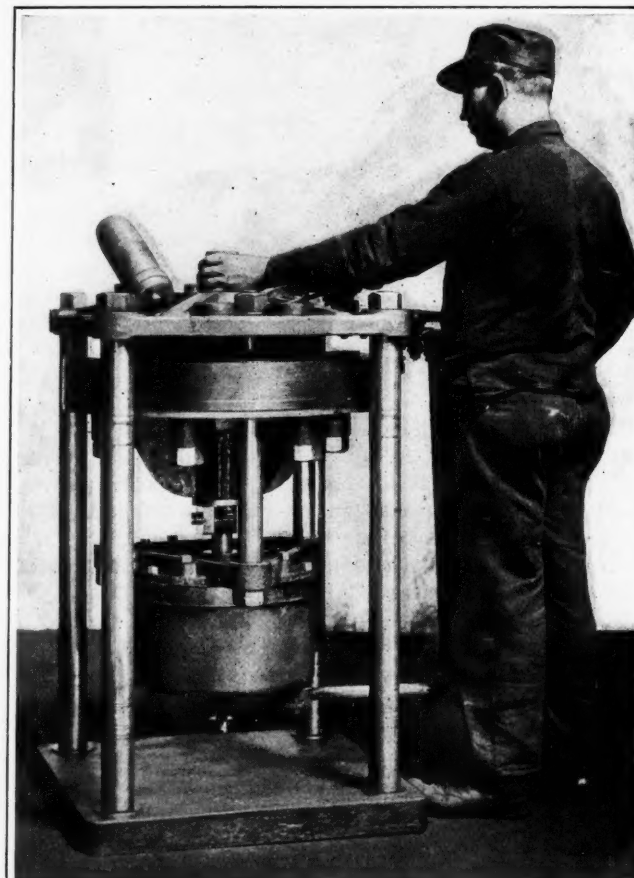


Williamson Metal-cutting Band Saw

which, in turn, makes the machine very simple to operate. As a result, inexpensive labor can be employed and one operator can run several machines.

MOTCH & MERRYWEATHER SHRAPNEL SHELL BANDING PRESS

The pneumatic banding press which forms the subject of this article has been developed for the purpose of compressing the copper bands onto shrapnel shells. The action of the press is such that the dies strike a sharp blow and then exert a heavy pressure which is sufficient to force the copper band into a dovetail groove in the shell. The rate of production which may be obtained with this machine is only limited by the ability of the operator to handle the work. The actual time required to set the band on an 18-pound shrapnel shell is from 7 to 8 seconds, so that it will be evident that the greater part of the time required for doing this work is taken by the operator in setting up the machine for the compressing operation and removing the banded shell from the press. Where one operator has entire charge of the machine, he should be able to turn out at least one shell per minute; and with two operations to a machine, the rate of production ought to be from three to four shells per minute.



Motch & Merryweather Shrapnel Shell Banding Press equipped with Nosing Attachment

The machine is self-contained, and in setting it up it is merely necessary to connect the air line in the shop to the control valve on the machine. A "nosing" attachment is provided, which consists of a thimble carried over the ram of the press. When this attachment is used, the shell is put in the same position as it would occupy when having the copper band put on, but for the "nosing" operation the shell is forced up by the air cylinder so that its end is compressed by entering the nosing thimble. The principal dimensions of the machine are as follows: Air pressure required, 100 pounds per square inch; floor space occupied, 30 by 30 inches; and weight of machine, 1750 pounds. The Motch & Merryweather Machinery Co., 707-715 Lakeside Ave., N. W., Cleveland, Ohio, has the exclusive sales agency for this press.

STORAGE BATTERY TRUCK

In the industrial truck which has been placed on the market by the Automatic Transportation Co., 258 Broadway, New York City, the feature of an elevating truck for use in connection with wooden loading platforms has been combined with motor drive. The truck is equipped with two three-horsepower motors, one of which does the driving while the other provides for raising the load by power. Both of these motors are connected to the same storage battery; and this battery has a sufficient capacity to drive the truck under maximum service conditions for a full working day.

The raising of the truck is done by means of four cams,

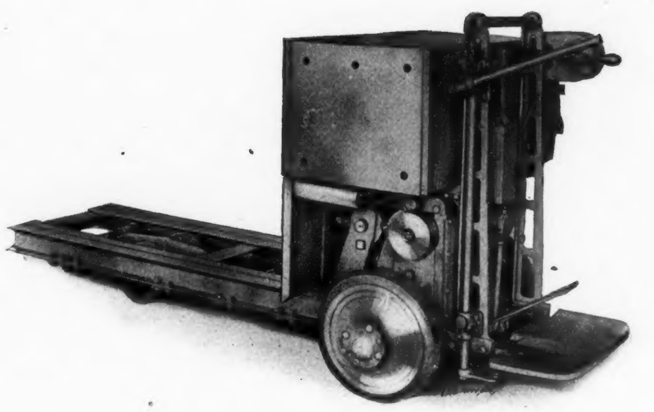


Fig. 1. Automatic Transportation Co.'s Storage Battery Truck

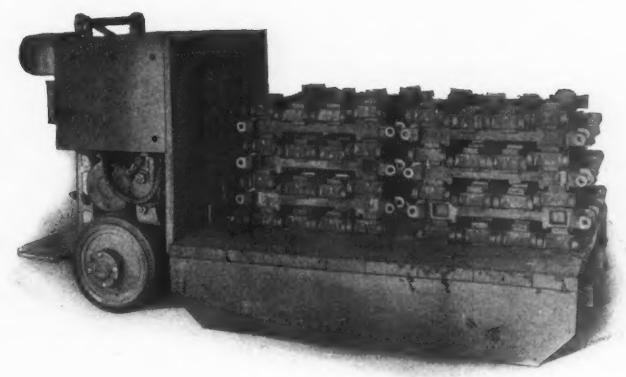


Fig. 2. Storage Battery Truck at Work

two of which are located at the front and two at the rear of the frame which goes under the loading platform. These cams are operated from the motor by means of a chain which can be seen in Fig. 1, and provide a lift of 3 inches. The motor is not used for lowering the load. For this purpose a band brake is provided on the motor shaft, and the lever which controls this brake provides for letting the load down slowly.

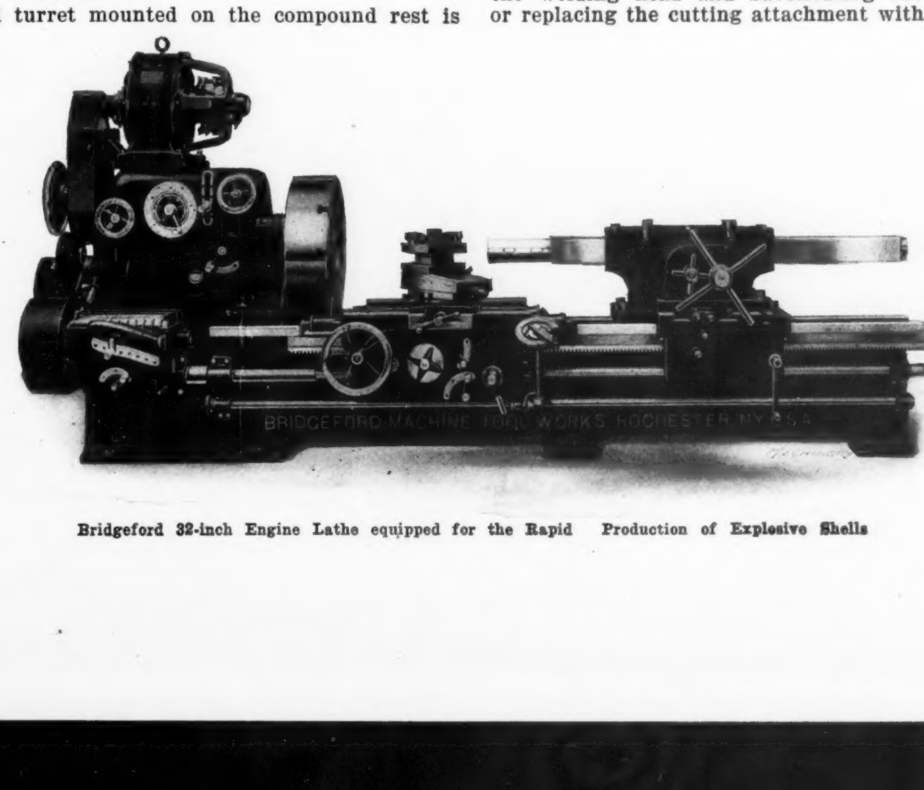
It will be noticed that a platform is provided on the truck, on which the operator stands while transporting a load from one department of the factory to another. The small wheels of the truck are 10 inches and the large wheels 15 inches in diameter. Rubber tires are provided on the wheels so that the truck runs quietly. The capacity is for loads up to 4000 pounds, and with such a load on the truck it can be driven at speeds up to 5 miles per hour.

BRIDGEFORD PROJECTILE LATHE

For use in turning and boring large explosive shells, the Bridgeford Machine Tool Works, Rochester, N. Y., has arranged the 32-inch heavy triple geared engine lathe of its manufacture with attachments which enable a high rate of production to be obtained on this class of work.

It will be seen that a power-fed tailstock is provided which adapts the lathe for boring large shells. The bar is 5½ inches in diameter and bored No. 7 Morse taper. It is arranged on a swivel so that either straight or tapered holes can be bored without using the taper attachment. Power for operating the bar is taken from the lead-screw and transmitted to the bar through gearing. In addition to the power feed, there is an arrangement by which the bar can be traversed by hand at either a low or high speed. For this purpose a large handwheel is employed, which drives direct for high speed or through back-gears for slow speed. The small handwheel provides for engaging or disengaging the power feed. The tailstock has a cross adjustment in addition to lateral adjustment along the bed.

A four-tool steel turret mounted on the compound rest is of great assistance in providing for the rapid and economical handling of the work. The lathe shown in the illustration is driven by an eighteen-horsepower Westinghouse variable-speed motor which is controlled from the carriage by the use of a Westinghouse drum type controller, placed on the rear of the frame. This enables the operator to control the motor from the carriage and change from slow to fast speed, or *vice versa*, without leaving the operating position. Without a motor, the headstock provides for fifteen mechanical speed changes, in geometrical progression; but when the lathe is equipped with variable-speed motor drive, these fifteen changes are multiplied by the number of points on the controller. The quick-change gear-box enables the operator to obtain any desired feed instantly. When equipped with side turning or full swing rests, this lathe is adapted for handling the machining operations on large shells advantageously.



Bridgeford 32-inch Engine Lathe equipped for the Rapid Production of Explosive Shells

NEW MACHINERY AND TOOLS NOTES

Staybolt Tap: Reinhold Betterman, Johnstown, Pa. A tapping device developed for rapidly tapping staybolt holes in internal fire-box boilers. Provision is made for overcoming the difficulty experienced in cutting the holes in proper alignment.

Duplex Milling Machine: C. F. Fulmer, Plainfield, N. J. A machine designed for slotting piston rings, which has a capacity for rings from 1½ to 14 inches in diameter. It is adjustable to 0.001 inch and is provided with a positive device for holding the work.

Quick-change Drill Chuck: Millholland Tool Co., Indianapolis, Ind. A quick-change chuck intended for use in machining work where drills, reamers, taps, etc., are required. The rapid manipulation of the chuck is the means of saving a considerable amount of time.

Heavy-duty Drill: Colburn Machine Tool Co., Franklin, Pa. A heavy-duty drill press equipped with a driving motor which has automatic starting control. A compound table is provided on the drill press, and the machine has a capacity for drilling holes up to 2 inches in diameter.

Fractiometer: Fractiometer Co., Rochester, N. Y. An instrument for use in adding and subtracting fractions, which is of simple construction, consisting of two celluloid disks, the outer one of which is held by hand while the inner is rotated to the desired position for the calculation to be made.

Welding and Cutting Torch: Imperial Brass Mfg. Co., Chicago, Ill. A torch in which the change from welding to cutting or *vice versa* can be conveniently made by removing the welding head and substituting the cutting attachment, or replacing the cutting attachment with the welding head, as may be required.

Emery Wheel Guard: William Plotz Iron Works, Cleveland, Ohio. A guard which may be easily clamped to any form of grinding wheel stand. In the event of the wheel bursting, the guard closes automatically to prevent the broken pieces from flying. This emery wheel guard is made in a number of different sizes.

Miter Cutting-off Machine: Grinden Art Metal Co., 427 Marcy Ave., Brooklyn, N. Y. A machine developed for use in making miter cuts on hollow steel molding. The cutting is done by an emery wheel 18 inches in diameter by 1/8 inch thick, and the machine is driven by an electric motor.

Cutting and Welding Torches: Modern Engineering Co., St. Louis, Mo. The important feature of these torches is the provision of an automatic spring closing or check valve, whereby the possibility of back-fire through the formation of an explosive mixture beyond the head is said to be entirely eliminated.

Automatic Grease Cup: Hunter Pressed Steel Co., Philadelphia, Pa. In this cup the grease is fed automatically by the use of compressed air, the action being supplemented by the force of a light compression spring. In this way a uniform action is provided which feeds the grease steadily down into the bearing.

Thread Limit Gage: C. L. Bailey, Glen Ridge, N. J. This gage has a frame of the C-type in which the hardened and ground measuring surfaces are clamped. On one side the measuring surface is continuous, while the "go" and "not go" surfaces on the opposite side are separate, with the required tolerance limit between them.

Cutting-off and Facing Machine: Williams Tool Co., Erie, Pa. This machine is particularly adapted for cutting off and facing shell forgings. The average speed of operation is estimated at 60 feet per minute, and running in this way a 4.5 shell forging can be faced in two minutes, and the open end cut off in slightly less than 30 seconds, when the wall is 3/8 inch thick.

Bench Die Grinder: Otto & Grayson Mfg. Co., Indianapolis, Ind. A bench machine for grinding dies, punches and similar work. The arbor is designed to carry small grinding wheels with a hole 1/2 inch in diameter. The bracket carrying the wheel has an overhang of 7 inches from the center of the spindle to the center of the column. The table of the machine is 12 by 12 inches in size.

Drinking Fountain: Allen Filter Co., Toledo, Ohio. A bubbling fountain and water cooler especially designed for shop use. The cooler box has double galvanized iron walls insulated with granulated cork. A coil tinned both inside and out carries the water through the cooler, the coil being submerged in the ice-cold water. The ice is inserted in one piece, and placed on top of the coil.

Portable Electric Drill: A. F. Carver & Co., Newtonville, Mass. A tool with a capacity for drilling holes up to 1/2 inch in diameter in steel. The motor is designed to run on alternating current, and is of the slow speed type. A push button control switch is located in the side handle, and the frame and spade handle are made of aluminum to reduce weight. The weight of the tool is 22 pounds.

Vertical Shrapnel Milling Machine: George Gorton Machine Co., Racine, Wis. A special high-speed vertical milling machine designed especially to meet the requirements of milling the powder groove in the timing disks used in shrapnel shells. The table is equipped with a special fixture for holding the work and locating it properly. The capacity is approximately 1200 disks in a ten-hour day.

Reproducing Machine: Commercial Camera Co., Rochester, New York. A machine which provides a rapid, accurate, and inexpensive method of reproducing all sorts of copy, such as photographs, letters, maps, drawings, blueprints, etc. It not only has the advantage of doing the work far more rapidly than it could be done by hand, but there is absolute assurance that a true facsimile of the copy will be obtained.

Storage Battery Truck: Elwell-Parker Electric Co., Cleveland, Ohio. A factory truck driven by a motor which takes power from an electric storage battery. The truck is used in connection with inexpensive wooden or metal platforms upon which the work is stacked, so that it is only necessary to provide the number of trucks that are actually required for transferring the work from department to department.

Hand Punch and Shear: Whitney Metal Tool Co., Rockford, Ill. A hand punch designed for punching sheet metal, angles, etc., with the minimum amount of effort. The tool has a capacity for punching a 3/8-inch hole through a 1/4-inch metal plate. The hand-operated shear is suitable for all classes of sheet metal work, and is designed in such a way that the shear works equally well when cutting at the extreme point of the blades as it does at any other point.

Photograph Displaying Device: Corte-Scope Co., 5612 Carnegie Ave., Cleveland, Ohio. A device for use in exhibiting pictures of machinery or any other photographs. This device resembles a stereoscope, the particular advantage claimed for it being that the three dimensions of height, width, and depth can be shown quite clearly. This is obviously an advantage to the salesman who is showing a prospective customer the features of a machine which he is trying to sell.

Metallographic Grinding and Polishing Machine: Eimer & Amend, New York City. This machine was built according to specifications drawn by Henry Wysor, Lafayette College, Easton, Pa. It is essentially a duplex machine, being provided with three carborundum wheels for the rough, medium and finish grinding operations, and a brass disk for the polishing operation. The grinding wheels are carried on a horizontal shaft and the polishing disk on a vertical shaft.

Emery-band Grinders: T. P. Walls Tool & Supply Co., 75 Walker St., New York City. An endless-band type of grinder which provides for obtaining a straight grained finish and sharp corners on the work. The work to be finished is held lightly against the emery band, which is held absolutely flat. When one band is worn out a new one can be substituted instantly by simply releasing the tension between the pulleys. Leather buffing bands for polishing can also be used on this machine.

Machine for Photographing on Both Sides of a Sheet: Cameragraph Co., Kansas City, Mo. This company has recently brought out a machine which is capable of taking two separate photographs at the same time and printing them on opposite sides of the same sheet. The machine also provides for developing and fixing the photographs by the manipulation of a crank, and delivers the completed prints cut ready for drying without requiring the operator to immerse his hands in chemical baths or water.

High-resistance Electric Pyrometers: Bristol Co., Waterbury, Conn. A line of high-resistance electric pyrometers for measuring temperatures up to 3000 degrees F. The millivoltmeter movement is of the pivot jewel bearing dead-beat type manufactured by the Weston Electrical Instrument Co. Bristol base metal couples may be used with these instruments for measuring temperatures up to 2000 degrees F., while platinum, platinum-rhodium couples are used for temperatures from 2000 to 3000 degrees F.

Air Compressor: Ingersoll-Rand Co., 11 Broadway, New York City. A small high-pressure air compressor of the horizontal type, which is driven by a steam engine. The air cylinder is equipped with Ingersoll-Rogler air valves which are independent of any external operating mechanism. These valves allow high speeds to be employed and give a high compression efficiency; in addition they are almost silent in operation. This type of valve is now used on all the air compressors of this company's manufacture.

Non-rusting Steel: Firth-Sterling Steel Co., McKeesport, Pa. A steel which will not rust or stain, so that it is particularly adapted for use in the manufacture of cutlery. This steel was originally made by Thomas Firth & Sons, Ltd., Sheffield, England, and was developed for use in making pump rods for colliery work. The breaking strength is from 50 to 55 tons per square inch with an elongation of 20 per cent and a reduction in area of almost 60 per cent. Hardening increases the tensile strength to about 100 tons per square inch.

Sand Blasting Machine: Mott Sand Blast Mfg. Co., New York City. This machine is for use in cleaning castings and is particularly adapted for intricate cored work, castings where the sand has been burned hard in the corners, thin malleable iron or steel castings, etc. The apparatus is so arranged that the nozzle or nozzles are moved across the face of the castings while they are being rolled in a tumbling barrel, so that the result is essentially the same as that obtained by an operator who turns the casting and moves the nozzle by hand.

Power Indicator: American Pulley Co., Philadelphia, Pa. A sensitive indicator for determining the horsepower required to run unloaded pulleys. This apparatus is interposed on the shaft between the driving pulley and the pulley to be tested. It consists of two disks, one of which is driven by the other by means of the free end of a flat spring attached to the driving disk, which presses against a pin on the driven disk. The relative position of the two disks when loaded is determined by the pressure on the spring, which is indicated by a pin moving over a scale that has been calibrated to indicate horsepower.

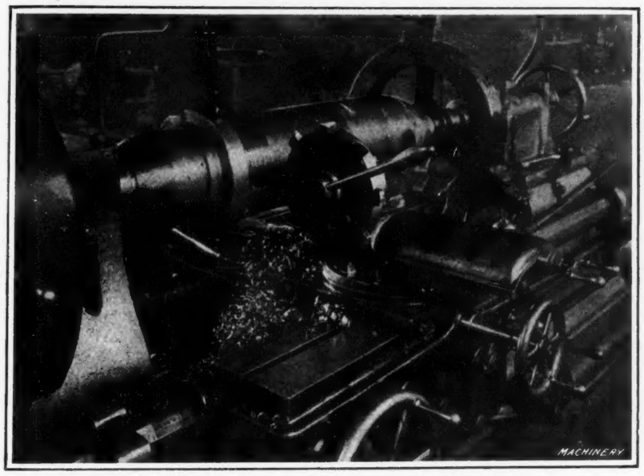
Lathe Chuck: Thomas Elevator Co., Chicago, Ill. A hand-operated lathe chuck which can be placed on a machine or removed as easily as a faceplate. A hand lever, cams and arms within the shell of the chuck are so arranged that a short initial movement of the lever moves the jaws from the fully opened position to a point where they are nearly in contact with the work; and the remaining movement of the lever moves the jaws slowly into contact with the work, giving a high holding pressure. Cams may be cut to give practically any distance of jaw movement within the range of the chuck without changing the gripping pressure of the jaws obtained by the final hand lever movement.

* * *

The chemists of the United States Bureau of Mines have discovered a process whereby radium can be produced at one-third its present cost; or at a price of $40,000 per gram instead of $120,000. Radium is much sought after because of its supposed curative qualities and its remarkable chemical activity. One grain of it evolves sufficient heat to raise its own weight of water from the freezing point to the boiling point every forty-five minutes.

SHEARER VERTICAL TURRET ATTACHMENT

When work is being machined on an engine lathe, which requires forming, grooving, beveling, beading, and similar operations to be conducted in sequence, the vertical turret



Shearer Vertical Turret Attachment for Engine Lathe

attachment which has been patented by George T. Shearer of Augusta, Ga., will be found the means of saving a considerable amount of time. It will be seen that this attachment consists of a vertical head clamped to the carriage of the lathe, and that it has a capacity for eight tools. The tools are held in dovetailed grooves by beveled clamp-bolts, which method of fastening provides a very secure grip. When in operation, the cross-feed is brought up against a stop fastened to the lathe carriage and the graduation on the feed-screw is then turned to zero, the purpose of this adjustment being to insure having the same tension on all tools. The fine adjusting screw which is provided behind each tool enables the operator to set all the tools to cut at exactly the same distance from the center of the work. By releasing the handle, the turret may be turned toward the operator, and when the correct tool is brought to the working position the turret is clamped.

The accompanying illustration shows the turret attachment engaged in turning a copper band on a 10-inch projectile, this band being turned from the rough and finished to within 0.002 inch of the required size in less than nine minutes, without requiring the use of calipers. It is claimed for the attachment that it will do 60 per cent more work than can be obtained from a machine which is not equipped in this way. The attachment may be easily removed from the lathe by loosening two clamp-bolts.

* * *

TESTING HARDNESS AND ELASTICITY OF RUBBER

The physical properties of rubber used for automobile tires are so different from those of all substitutes which have been tried that a saying has arisen to the effect that "the only substitute for a rubber tire is another rubber tire." But the properties that make rubber so serviceable may vary to such an extent that tires made of unsuitable grades of rubber are little better than many tires made from inferior substitutes. The steadily increasing demands for uniformity in tires, which are made by automobile engineers, have created a demand for accurate instruments for testing the rubber in order to determine whether or not it is up to the required standards.

Hardness and elasticity are the two principal physical properties of rubber that are of importance as regards its application in tires. The Shore Instrument & Mfg. Co., 557 West 22nd St., New York City, took up the problem of developing instruments for determining these properties, with the result that the "durometer" and "elastometer" have recently been placed upon the market. These instruments are shown in Fig. 1, and they can be used free-hand, or in con-

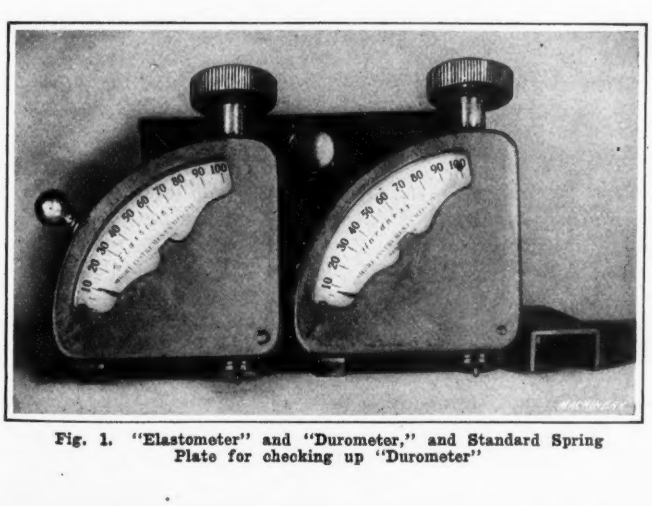


Fig. 1. "Elastometer" and "Durometer," and Standard Spring Plate for checking up "Durometer"

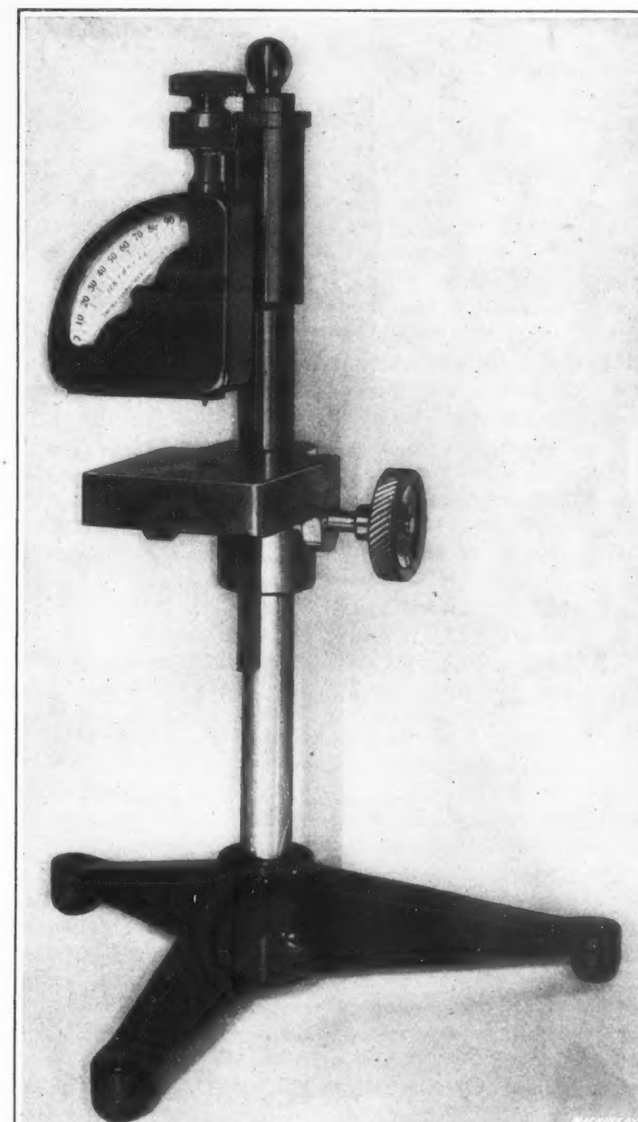


Fig. 2. "Durometer" mounted on Stand ready for Use

nection with a stand of the form shown in Fig. 2. The "durometer" is used for testing the hardness of rubber, while the "elastometer" measures the elasticity of the material.

The hardness is measured in terms of the resistance offered by the rubber to the depression of a blunt pin into it by means of a standard spring. The surface of the rubber is not broken to any extent, so that the "durometer" is adapted for testing the quality of finished products without damaging them. The "elastometer" measures elasticity in terms of resistance to permanent depression or tearing. For this purpose, a moderately sharp point is caused to penetrate the rubber to a fixed depth. If the rubber is perfect, no tearing or permanent injury of the material will result, and consequently the point will be completely ejected when the pressure on the pin is released. The extent to which the rubber

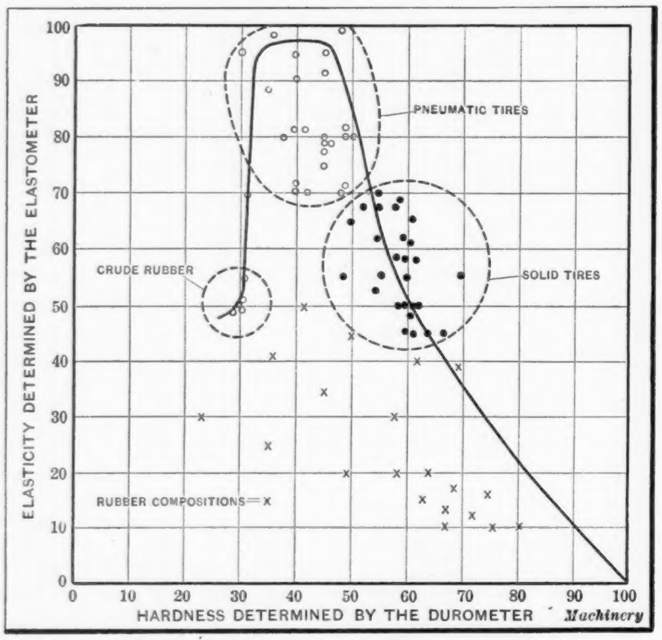


Fig. 3. Chart showing Relation of Hardness to Elasticity for Different Tires and Materials

recovers after imposing this test indicates the percentage of elasticity.

The importance of an accurate method of measuring the hardness and elasticity of rubber can be realized when it is known that if rubber is vulcanized in such a manner that the maximum elasticity is reached, while the hardness is too low for the conditions of service, each degree of hardness is obtained by sacrificing about 3 degrees of elasticity, as shown in the chart reproduced in Fig. 3. This loss of elasticity continues to such an extent that if solid tires are hardened sufficiently to carry the maximum load, so much of the elasticity of the rubber is sacrificed that the efficiency of the tires is very seriously impaired.

* * *

KRAUS INTERNAL COMBUSTION ENGINE FOR MARINE USE

A novel type of internal combustion engine has been invented by Otto Kraus of the Kraus Engine Co., 218 W. 26th St., New York City, which is believed to be particularly adapted for marine use, owing to its compactness and the fact that it utilizes crude oil or other low-grade oils. The interesting feature of the engine is that the combustion of the oil occurs in a separate chamber (corresponding to the steam chest of a steam engine) and not in the cylinders. In this combustion chamber the oil is injected and atomized and is mixed with a suitable quantity of water; a greater quantity of air than is actually required for combustion is also forced into the chamber by an air compressor driven from the crankshaft of the engine. The steam and gases of combustion are admitted to the cylinders by means of ordinary piston valves which are operated on the experimental motor by the Joy type of valve gear.

An electric spark ignites the atomized oil which is mixed with the compressed air; as soon as the engine is running, the current is turned off, since continuous combustion takes place without it. Only one spark plug is required regardless of the number of cylinders. In starting the engine, no previous heating is necessary and the starting may be done by the use of compressed air, which the engine itself provides by means of a tank attached to the engine. The speed is controlled by a throttle and it is reversed by a reversing lever the same as a steam engine. The power is exerted in both directions on each piston and the pressure in the cylinder is practically constant up to the point of cut-off. The engine uses kerosene, crude oil, or any fuel oil, and it is claimed that perfect combustion is obtained. No matter what fuel is used, it is said that there are no carbon deposits and the exhaust is odorless.

ANNUAL CONVENTIONS A. R. M. M. AND M. C. B. A.

The forty-eighth annual convention of the American Railway Master Mechanics' Association and the forty-ninth annual convention of the Master Car Builders' Association were held in Atlantic City, N. J., June 9-11, and June 14-16, respectively. The headquarters of the convention was Young's Pier, where the daily sessions of the conventions were held and the entertainments of the evenings were enjoyed. A large section of the pier, about 70,000 square feet, was given over to the exhibits of the members of the Railway Supply Manufacturers' Association. These exhibits represented the latest developments in railway supplies and devices including locomotive, car, track, and shop materials, as well as the tools and machines used in general railroad shop practice. The machine tool exhibit, while interesting, was not as large as in previous years, the reason being undoubtedly due to the fact that the machine tool builders in general are unusually busy and not as keen for railway business as in former years. While the delegates to the convention showed considerable interest in the machine tool exhibit, it was the consensus of opinion that buying by the railroads, at least of machine tool equipment, has not actively begun.

Among the reports and papers of the American Railway Master Mechanics' Association convention were the following:

June 9—Mechanical Stokers; Revision of Standards; Safety Appliances; Advantages of Compounding Superheated Locomotives; Side Bearings on Fenders; Smoke Prevention.

June 10—Locomotive Headlights; Design, Construction, and Inspection of Locomotive Boilers; Standardization of Tinware; Superheater Locomotives; Fuel Economy; Variable Exhausts, by J. Snowden Bell; Tender Derailments, Causes and Remedies, read by H. P. Bentley; Road Instructions for Engine Men and Firemen; Cross-head Design, discussion led by A. R. Ayers.

June 11—Discussion of reports on joint meetings with M. C. B. Association; Standardization of Tinware; Revision of Air Brake and Train Signal Instruction; Train Resistance and Tonnage Ratings; Locomotive Counterbalancing; Maintenance and Operation of Electrical Equipment; Forging Specifications; Boiler Washing; Dimensions of Flange and Screw Couplings for Injectors.

At this session the officers for the year were elected as follows: E. W. Pratt, president; William Schlafge, first vice-president; F. H. Clark, second vice-president; W. J. Tollerton, third vice-president; Angus Sinclair, treasurer; C. H. Hogan, J. F. De Voy and J. T. Wallis, executive committee.

The sessions of the Master Car Builders' Association convention were held June 14, 15 and 16, and the principal papers and discussions were as follows:

June 14—Revision of standards and recommended practice; train brake and signal equipments; brake shoe and brake beam equipment; car wheels; arbitration committee's report; revision of prices of labor and material; settlement prices for reinforced wooden cars; compensation for car repairs.

June 15—Discussion of reports on couplers; safety appliances; rules for loading material; overhead inspection; interline inspection; car construction; specifications and tests for materials; tank cars; paper by Paul Synnestvedt, "What is the Value of a Patent?"

June 16—Discussion of reports on train lighting and equipment; car trucks; draft gear; paper on "Impact between Freight Cars in Switching Service," by Prof. L. E. Endsley; topical discussion, "Air Brake Maintenance." At this session a joint meeting with the A. R. M. M. Association was held.

The following officers for the year were elected: President, D. R. MacBain, superintendent of motive power, New York Central Lines West of Buffalo; first vice-president, R. W. Burnett; second vice-president, C. E. Chambers, superintendent of motive power, Central Railroad of New Jersey; third vice-president, J. W. Demarest, superintendent of motive power, Pennsylvania Lines West of Pittsburg, Northwest System; treasurer, J. S. Lentz, Lehigh Valley Railroad.

Among the two hundred and twenty-seven concerns exhibiting or maintaining reception booths, the following exhibited machine tools, machine shop equipment or supplies:

Alston Saw & Steel Co., Folcroft, Pa. Alston hacksaw blades with demonstration of cutting qualities.

H. Boker & Co., Inc., New York City. High-speed and tool steel; steel specialties.

C. H. Besly & Co., Chicago, Ill. Patternmaker's disk grinder; motor-driven disk grinder for metal surfacing, etc.

C. & C. Electric & Mfg. Co., Garwood, N. J. Demonstration of electric arc welding outfit.

Duff Mfg. Co., Pittsburg, Pa. Duff ball bearing screw jack; car jacks; ratchet jacks; hydraulic jacks.

Greenfield Tap & Die Corp., Greenfield, Mass. Demonstration of self-opening dies, tapping chucks, etc. Samples of staybolt taps and illustrations of staybolt tapping operations.

Greene, Tweed & Co., New York City. "Favorite" reversible ratchet wrench; packings for piston rods, valves, pumps, etc.

Greenfield Machine Co., Greenfield, Mass. Cylindrical grinding machine; cutter grinding machine.

Ellsworth Haring, New York City. High-speed steel; tool steel; steel specialties.

Edwin Harrington, Son & Co., Inc., Philadelphia, Pa. Chain hoists.

Ingersoll-Rand Co., New York City. Pneumatic riveting and chipping hammers; "holder-ons"; sand rammers; motor hoists.

William Jessop & Sons, Inc., New York City. Jessop's steel.

H. W. Johns-Manville Co., New York City. Lagging, pipe coverings, packings, gaskets, etc.

Landis Machine Co., Waynesboro, Pa. Pipe threading and cutting-off machines; grinder for chasers and bolt cutters.

Lucas Machine Tool Co., Cleveland, Ohio. "Precision" horizontal boring, drilling and milling machine.

Manning, Maxwell & Moore, Inc., New York City. Putnam car wheel boring mill; geared head lathe; double axle lathe; journal turning lathe; etc..

National Machinery Co., Tiffin, Ohio. Forging machine; bolt cutter; automatic nut tapping machine.

Niles-Bement-Pond Co., New York City. Niles 44-inch vertical boring mill; Bement 60-inch horizontal milling machine.

A. O. Norton, Inc., Boston, Mass. High-speed jack.

R. D. Nuttall Co., Pittsburg, Pa. Heat-treated gears and pinions for railway use; pantograph trolley for electric railway use.

Nutter & Barnes Co., Hinsdale, N. H. Cutting-off saw; abrasive metal cutting machine; saw sharpener, etc.

Stockbridge Machine Co., Worcester, Mass. 20-inch motor-driven Stockbridge crank shaper.

U. S. Metal & Mfg. Co., New York City. "Cayuta" ball and cone bearing screw jack.

Warner & Swasey Co., Cleveland, Ohio. No. 2A universal hollow hexagon turret lathe; 3A universal hollow hexagon turret lathe.

Yale & Towne Mfg. Co., New York City. "Yale" triplex hoists, trolleys, etc.

* * *

CONVENTION OF N. A. C. S.

The third annual convention of the National Association of Corporation Schools was held in Worcester, Mass., June 8 to 11, with headquarters at the Bancroft Hotel. Practically the whole time was given over to business meetings, reports, and discussions. The Tuesday morning session began with an address of welcome by George I. Alden, president of the Norton Co., and by Hon. George M. Wright, mayor of Worcester. Charles P. Steinmetz, chief advisory engineer of the General Electric Co., and president of the National Association of Corporation Schools, then presented his annual address, after which the various annual reports were read. During subsequent meetings, reports of the committees on trade apprenticeship schools, special apprenticeship schools, public education, vocational guidance, office work schools, advertising, selling and distribution, employment plans, and safety, hygiene and cooperation, were presented. After each report, about two hours was allowed for discussion, so that each subject was very thoroughly dealt with. On June 8 an inspection was made of the Worcester Boy's Trade School in the afternoon, and on June 9 the plants of the Norton Co. and the Norton Grinding Co. were inspected by the delegates and visitors. A supper was served in the open, and after the supper the Norton Co. provided an entertainment that was highly appreciated. Later a session was held in the Norton Co.'s administration hall. Extensive exhibits of educational value and interest were arranged for on the mezzanine floor of the Bancroft Hotel. The convention undoubtedly proved of especial value to all the delegates interested in corporation and trade school work. Representatives of public schools were also present at many sessions.

SPRING MEETING OF A. S. M. E.

The spring meeting of the American Society of Mechanical Engineers was held in Buffalo, N. Y., June 22-25, the Hotel Statler being the headquarters. On Tuesday evening an address of welcome was made by Frank B. Baird, representing the industries of Buffalo, to which John A. Brashear, president of the society, responded. An informal reception and reunion followed. On Wednesday, June 23, the party went to Niagara Falls by special trolley cars, where a business meeting was held in the auditorium of the Shredded Wheat Co.'s factory. At this meeting, the following papers were presented:

"The Study of a Shaft and Its Improvement by Heat-treatment," by John Younger.

"A Comparison of the Properties of Nickel, Copper and Manganese Steel," by Robert R. Abbott.

"Use of Corrugated Furnaces for Vertical Fire-tube Boilers," by F. W. Dean.

"On Measuring Gas Weights," by Thomas E. Butterfield.

The afternoon was spent in an inspection of the attractions of Niagara Falls, the power plants on the Canadian and American side, etc. Wednesday evening Dr. F. H. Newell, formerly chief of the U. S. Reclamation Service, gave an illustrated lecture on "The Engineer as a Citizen" in the ball room of the Hotel Statler. Thursday forenoon was devoted to professional sessions at which the following papers were presented:

"Rational Design and Analysis of Heat Transfer Apparatus," by E. E. Wilson.

"Influence of Disk Friction on Turbine Pump Design," by F. zur Nedden.

"Surface Condensers," by C. F. Braun.

"Some Mechanical Features of the Hydration of Portland Cement and the Making of Concrete as Revealed by Microscopic Study," by Nathan C. Johnson.

"Design of Rectangular Concrete Beams," by Howard Harding.

"Model Experiments and the Forms of Empirical Equations," by Edgar Buckingham.

"The Effect of Relative Humidity on an Oak Tanned Leather Belt," by W. W. Bird and F. W. Roys.

Thursday afternoon was devoted to sight-seeing trips, etc. The reception and dance, the leading social function of the spring meeting, was held in the ball room of the Hotel Statler Thursday evening. Friday morning, at the professional session, the following papers were presented:

"Laws of Lubrication of Bearings," by M. D. Hersey.

"Relation between Production and Costs," by H. L. Gantt.

"Laps and Lapping," by W. A. Knight.

The regular nominating committee announced the following nominations of officers for election next fall: D. S. Jacobus for president; J. Sellers Bancroft, Julian Kennedy and W. B. Jackson for vice-presidents; H. de B. Parsons and John A. Stevens for managers.

* * *

In an address before the Patent Bar Association, at Chicago, Thomas Ewing, commissioner of patents, called attention to the great number of interferences that are a constant source of trouble to the examiners and applicants. There are forty-three primary examiners who declare interferences wherever it is thought necessary. Each examiner who declares an interference also hears the motions to dissolve it, so that an interference once started can only be dissolved by inducing the examiner to reverse himself. This has caused serious criticism of the patent system. Of late, one of the two law examiners that aid in the work of the patent commissioner has been devoting his entire time to going over all proposed interferences with the examiners before these interferences were declared. The result has been that twenty-five per cent of interferences proposed by the examiners have never been declared. In order to effect this reduction a practice has also been tried of not establishing interferences where the difference of dates of filing of the applications involved exceeds two years. It has been found that where the difference of filing dates exceeds one year, the party filing the application first has won in nearly all cases.

CHART RECORDING MECHANIC'S PROGRESS

The cause of progress in life might be summed up in one word—discontent. Be discontented with your present condition if you would change to a better one. Every ambitious person is discontented—for if he were not he would not strive so hard to change to a more agreeable environment. Contentment is a foe to progress, and ambition is commendable provided it is rightly directed. Many a mechanic has been contented to remain a journeyman because he was well satisfied. If he had been discontented he would have gone ahead, made a name for himself and perhaps died rich enough to endow a few libraries.

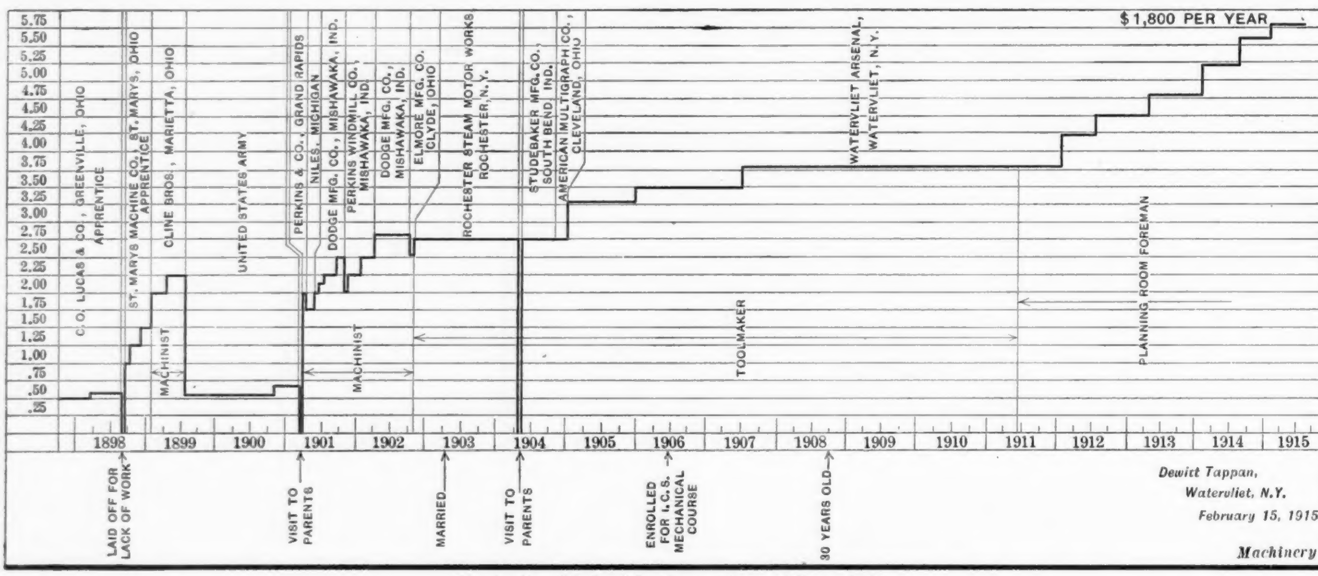


Chart of a Mechanic's Career from 1898 to 1915

It is the custom to take inventory of stock once a year, and it is a good plan for every individual to occasionally take stock of himself and his resources, and to record progress made. The simplest way of keeping a record of progress is to draw a chart, showing year by year, income, occupation, position and other data of interest. The accompanying chart, furnished by Dewitt Tappan, Watervliet, N. Y., is an excellent example of a personal record and is one showing satisfactory progress, but one not without ups and downs such as most mechanics experience—at least in their early years following apprenticeship. It will be noted that in 1906 he enrolled for a home study course in mechanical engineering and that substantial advancement in salary has been achieved since. Mr. Tappan has been a reader of and a contributor to MACHINERY for many years.

The executive of a great railway system has compiled a chart recording his personal career, and while it shows extraordinary and rapid advancement, a very significant feature is that the advancement was most notable at the time when he became a contributor to the railway technical journals. His contributions advertised his personality and writing stimulated his mental activities. Employers should take notice of this fact, especially the heads of the larger manufacturing concerns who have displayed in late years a tendency to stifle the ambitions of certain of their employes to contribute articles or papers for publication. This policy was adopted by employers for fear that certain "trade secrets" would be revealed and their business injured by giving advantages away to their competitors. This policy, like most other repressive measures, is likely to prove harmful to the concerns responsible. Ambition and mental activity are deadened, and employes who might have been leaders become unambitious and unfruitful except as they produce in the treadmill of daily work.

* * *

THE SHORT-PAID POSTAGE NUISANCE

The subject of short-paid postage on foreign mail has been reported upon by consular officers at such length and with such frequency that further discussion would seem needless. That the practice still continues and that possible purchasers of American goods are still annoyed by the receipt of underpaid letters from the United States is shown by a communication from F. St. Austell, editor of the *International Trade Developer*, who writes:

"Mr. Dunn, secretary of the Pan American States Association, recently received from William E. Jessup, a resident of Guatemala, a package containing 140 underpaid envelopes sent to him in one month by merchants of the United States who wish to sell their goods in Guatemala. Mr. Jessup states that his only reason for taking these 140 letters from the post office and paying the extra postage was that he might send the entire lot to Mr. Dunn as an object lesson to exporters."

* * *

PERSONALS

Clyde M. Carr, president of Joseph T. Ryerson & Son, Chicago, Ill., has returned to Chicago from Santa Barbara, Cal.

Prosper J. Hoeffler has taken a position with the Lumen Bearing Co., Buffalo, N. Y., as a salesman of babbitts and solders.

H. A. Flagg, formerly sales manager of the tubing department of the Standard Welding Co., Cleveland, Ohio, has been made general sales manager in charge of all sales, orders and branch offices.

S. W. Hartley, formerly sales manager of the Standard Welding Co., Cleveland, Ohio, has been made manager of production, in charge of all manufacturing orders, raw materials and finished parts.

Edward S. Wales-Smith, for many years traffic agent of the American Express Co., with an office in Paris, France, has been sent to Petrograd, Russia, for the purpose of developing Russian trade with the United States.

J. E. MacArthur, formerly connected with the Pierce-Arrow Motor Car Co., and more recently superintendent of the Keystone Mfg. Co., Buffalo, N. Y., resigned May 1 to become general superintendent of the Robinson Fire Apparatus Mfg. Co., St. Louis, Mo.

W. C. Tharp has been appointed district manager of the Hoskins Mfg. Co.'s Pittsburg office, succeeding I. J. Shults, resigned. Mr. Tharp has been associated with the Republic Iron & Steel Co., the Scientific Materials Co. and the Metallurgical Testing Laboratory of Pittsburg.

Holden A. Evans has been made general manager of the Baltimore Dry Dock & Shipbuilding Co., Baltimore, Md. This company recently acquired the two ship-building plants and other properties of the Skinner Shipbuilding & Dry Dock Co., of which Mr. Evans had charge for the past year.

A. B. Hazzard, for six years general manager of the J. Morton Poole Co., Wilmington, Del., and later one of the staff of managers of the Detroit Engine Works, Detroit, Mich., is now engineer of the Falcon Motor Truck Co. of Detroit. This company has recently put a light delivery motor truck of from 1000 to 1200 pounds capacity on the market.

H. T. Matthew has been appointed Pacific Coast representative of the Society for Electrical Development, 29 W. 39th St., New York City. Mr. Matthew was for six years business manager of the *Electrochemical Industry*, and later western manager of the *Electrical World*. For the past three years

he has represented the McGraw publications on the Pacific Coast.

A. T. Spencer, export trade agent of the American Express Co., New York City, sailed for Europe in May with the intention of visiting the principal ports on the Baltic Sea, as well as Petrograd, Libau, Riga, Moscow, Archangel, and other Russian cities. Mr. Spencer will cooperate with Edward S. Wales-Smith in his work of placing Russian importers in touch with American manufacturers.

Herbert H. Rice, formerly vice-president of the Waverley Co., electric vehicle manufacturer of Indianapolis, Ind., has been made president of the company, following the retirement of William B. Cooley. Mr. Rice was graduated from Brown University in 1892, and received his training with Col. Albert A. Pope in the early days of the bicycle business. In 1904 he was sent to Indianapolis to take charge of the Waverley factory, then recently acquired by the Pope Motor Car Co. About the same time, Wilbur C. Johnson, also of the Pope Motor Car Co., joined the Waverley branch and he now becomes vice-president of the reorganized Waverley Co.

OBITUARIES

George M. Russell, advertising manager of J. H. Williams & Co., Brooklyn, N. Y., died at his home in Brooklyn, April 22, aged fifty-four years. Mr. Russell had been connected with J. H. Williams & Co. for twenty-four years, first as purchasing agent and then as advertising manager. He leaves a widow, a son and daughter.

Elmer Crawford, president and founder of the Crawford Publishing Co., Chicago, Ill., and editor of *Mill Supplies*, died in Chicago, June 15, from heart failure. Mr. Crawford was born in Michigan in 1862, graduated from the law school of the University of Michigan in 1886, and was later admitted to the bar of that state. In 1899 he became connected with the *Tradesman*. The following year he associated himself with *Domestic Engineering*, and in 1910 he established the Crawford Publishing Co. and became its president and editor of *Mill Supplies*. He is survived by his wife, a daughter, and son.

COMING EVENTS

August 17.—Annual meeting of the International Railroad Blacksmiths' Association, Philadelphia, Pa. A. L. Woodworth, secretary-treasurer, C. H. & D. Railway, Lima, Ohio.

September 7-10.—Twenty-third annual convention of the Traveling Engineers' Association, Hotel Sherman, Chicago, Ill. W. O. Thompson, secretary, East Buffalo, N. Y.

September 9-11.—Swedish engineering convention in the United States; meeting in Chicago. Secretary, Eastern organization committee, E. Oberg, 183 68th St., Brooklyn, N. Y.; secretary Western organization committee, C. G. Axell, 601 City Hall Square Bldg., Chicago, Ill.

September 25-October 2.—Annual exhibit of the Foundry & Machine Exhibition Co., Atlantic City, N. J., in conjunction with the American Foundrymen's Association convention. Foundry & Machine Exhibition Co., 1949 W. Madison St., Chicago, Ill.

September 27-October 1.—Annual convention of the American Foundrymen's Association, Atlantic City, N. J.

SOCIETIES, SCHOOLS AND COLLEGES

Beloit College, Beloit, Wis. Catalogue for 1914-15.

University of Vermont, Burlington, Vt. Catalogue for 1914-15.

Louisiana State University, Baton Rouge, La. Catalogue 1915-1916.

Montana State School of Mines, Butte, Montana. Catalogue for 1915-16.

Upper Iowa University, Fayette, Iowa. Bulletin containing catalogue for 1914-1915.

Lowell Textile School, Lowell, Mass. Quarterly bulletin containing catalogues for 1915-16.

Newberry College, Newberry, S. C. Catalogue for 1914-1915 and announcements for 1915-1916.

Princeton Summer School, Princeton, N. J. Announcement of the twenty-fourth annual session which opens July 12. Address C. R. Morey, Princeton, N. J.

National Founders' Association, M. W. Alexander, chairman, West Lynn, Mass. Bulletin 23: "Good Light—An Important Safety Factor." This bulletin was approved by the conference board on Safety and Sanitation, composed of the National Founders' Association, the National Association of Manufacturers, the National Metal Trades Association, and the National Electric Light Association. It is a short treatise on artificial lighting in foundries, dealing with the various forms of lighting that have been used successfully for foundry installations.

NEW BOOKS AND PAMPHLETS

The Pennsylvania Railroad—Its Policies Toward Its Employes. 60 pages, 6 by 9 inches. Published by the Pennsylvania Railroad, Philadelphia, Pa.

Standards for Gas Service. 197 pages, 7 by 10 inches. Published by the Department of Commerce, Washington, D. C., as Circular of the Bureau of Standards 32, third edition.

Location of Ford Model T Engine Troubles Made Easy. Wall chart, 23 by 30 inches. Published by the Norman W. Henley Publishing Co., New York City. Price, 25 cents.

Proposed National Electrical Safety Code. 137 pages, 7 by 10 inches. Published by the Department of Commerce, Washington, D. C., as Circular of the Bureau of Standards No. 54.

Safety Rules to be Observed in the Operation and Maintenance of Electrical Equipment and Lines. 50 pages, 7 by 10 inches. Published by the Department of Commerce, Washington, D. C., as Circular of the Bureau of Standards No. 49.

The Effect of Boron Upon the Magnetic and Other Properties of Electrolytic Iron Melted in Vacuo. By Trygve D. Yensen. 19 pages, 6 by 9 inches. Illustrated. Published by the Engineering Experiment Station, University of Illinois, Urbana, Ill., as Bulletin 77. Price, 10 cents.

Yearbook of the Department of Agriculture—1914. 715 pages, 6 by 9 inches. Illustrated. Published by the Department of Agriculture, Washington, D. C.

This government publication contains much useful information for the homes of all classes of citizens.

Steam-Boiler Explosions. By William H. Boehm. 24 pages, 6 by 9 inches. Illustrated. Published by the Fidelity & Casualty Co., New York City.

This short treatise on steam-boiler explosions, their causes and the destructive effects following explosions, should be in the hands of every steam engineer and fireman, and manager of plants having steam boilers.

South American Handbook. 75 pages, 6 by 9 inches. Published by the National Foreign Trade Council, 64 Stone St., New York City. Price, 25 cents.

This pamphlet is a compilation of information and statistics regarding the public investment, foreign and railway development of the South American republic. It was compiled for the benefit of business men who are turning to American markets for the extension of trade.

Road Models. 24 pages, 6 by 9 inches. Illustrated. Published by the United States Department of Agriculture, Washington, D. C., as Bulletin 220.

The contents of this interesting and public document comprise Roman roads, French roads, macadam method of construction, Telford method of road building, location and alignment, foundations, earth and earth-clay roads, gravel roads, macadam roads, cement concrete roads, bituminous concrete roads, paved roads other than cement, culverts and bridges, roadside treatment, and road machinery.

Flywheel Explosions. By William H. Boehm. 24 pages, 6 by 9 inches. Illustrated. Published by the Fidelity and Casualty Co., New York City.

This pamphlet is a companion to the short treatise on steam-boiler explosions. Flywheel explosions are nearly as disastrous as boiler explosions. The average man little suspects what tremendous potential energy is set free when a large flywheel bursts. The author points out the weaknesses of flywheels, gives rules for speeds and recommendations which if followed would reduce the danger of flywheel explosions to a minimum.

Acme Automatic Multiple-Spindle Screw Machines—Design, Construction, Operation, Tool Equipment and Attachments. By Douglas T. Hamilton. 63 pages, 7 by 8¾ inches. 104 illustrations. Published by the National-Acme Mfg. Co., Cleveland, Ohio.

This treatise on the "Acme" automatic multiple-spindle screw machines is a revision of the articles published in MACHINERY from December, 1912, to November, 1913, inclusive. These articles treated of the design, construction, operation, tool equipment, attachments, examples and methods of setting up, and dealt intimately with the details a successful operator must be thoroughly familiar with. The treatise is one that screw machine operators generally, and operators of the National-Acme machine in particular, should heartily welcome.

Organization of Workshops and Factories. By Robert Grimshaw. 104 pages, 3½ by 5¼ inches. Published by the author, 1330 St. Nicholas Ave., New York City. Price, 50 cents.

This little work is an addition to the already long list of books on factory management and efficiency methods. It treats of the "nine principles" of organization, choice of system, calculating manufacturing cost, calculating material, measuring and recording time, distribution of time, time records, shortening time of manufacture, inspection, sources of material, ordering material, storerooms, personnel, filling vacant positions, machines, correspondence, new designs, prevention of accidents, day's wages, piecework, contractor system, profit sharing, premium systems, stock-keeping, etc.

Location of Carburetion System Troubles Made Easy. Chart by Victor W. Page. Published by the Norman W. Henley Publishing Co., New York City. Price, 25 cents.

This chart in the form of a wall hanger, 26 by 28 inches, gives a concise statement of the common derangements likely to develop in the carburetion system of an automobile power plant. It is intended to supplement the chart entitled, "Systematic Location of Gas Engine Troubles," recently published by the same company. The illustration shows the parts nearly full size, all being named in large type. The information is divided into two heads, "Motor Will Not Start" and "Loss of Power and Misfiring." The cause of the trouble and the remedy is given under each head for all the troubles likely to develop. There are also notes on carbureter adjustment.

A Study of Boiler Losses. By A. P. Kratz. 72 pages, 6 by 9 inches. 31 illustrations. Published by the Engineering Experiment Station, University of Illinois, Urbana, Ill., as Bulletin 78. Price, 35 cents.

The bulletin presents an analysis of the data obtained from a series of twenty-five trials made on a 500 H. P. Babcock & Wilcox boiler located in the heating plant of the University of Illinois. The boiler was operated under varying conditions of load and depth of fuel bed. Conclusions are drawn regarding the conditions necessary in order to secure the best continuous operation. Tests were also made using samples of coal which had been exposed to the weather for about six years. An interesting fact brought out was that no difficulty was experienced in burning weathered coal.

Short-Unit Courses for Wage Earners, and a Factory School Experiment. 93 pages, 6 by 9 inches. Published by the Department of Labor, Bureau of Labor Statistics, Washington, D. C., as Bulletin 159.

The bulletin contains a list of short-unit courses in various trades and occupations, and a discussion of their application to trade-extension work in part-time and evening schools. These short courses are intensified forms of instruction, intended to serve, in a limited number of lessons, the specific need of the particular group. Each unit deals with one part of the trade, and is complete in itself. The courses outlined include mechanical and electrical drawing, machine drawing, architectural drawing, drawing for sheet-metal workers, patternmaking, machine-shop mathematics, etc.

Banking and Credit in Argentina, Brazil, Chile, and Peru. By Edward N. Hurley. 77 pages, 6 by 9 inches. Published by the Department of Commerce, Bureau of Foreign and Domestic Commerce, Washington, D. C., as Special Agent's Series No. 90.

This government work should be of interest and value to many concerns now endeavoring to establish trade relations in South American countries. It is a report incorporating observations and conclusions from a manufacturer's point of view of the existing banking situation as related to present and future American trade in Argentina, Brazil, Chile and Peru. The functions of banks in South America are described, and the activities of the British, German and other European banks are dealt with; also banking and credit in Argentina, Brazil, Chile and Peru and methods of establishing American banks.

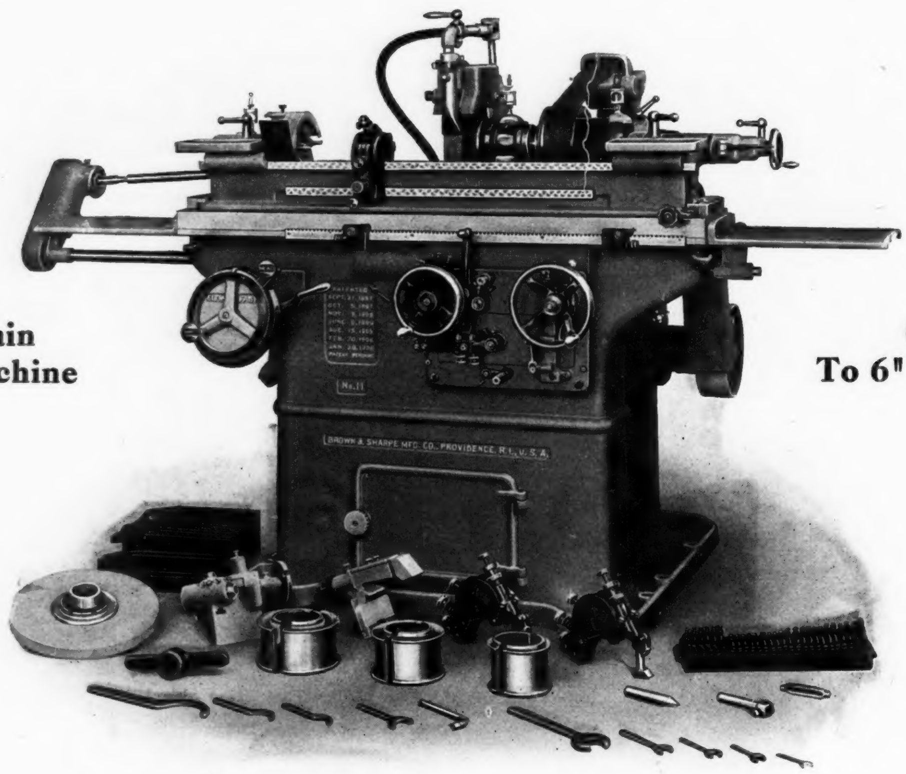
Elementary Drawing. By Charles W. Weick. 250 pages, 6 by 9 inches. 154 illustrations. Published by the McGraw-Hill Book Co., New York City. Price, $1.75.

The book under review aims to provide an elementary text-book for class use. The author, who is assistant professor of drawing and design at the Teachers College of Columbia University, has met the requirements for such a work in a very satisfactory manner The object of the book is to cover both theory and practice. The treatment of the theory in the text is as brief as clearness permits, but is handled in such a manner and illustrated with engravings of such a character that the meaning is always fully expressed. The conventions of the drawing-room are duly explained. The book comprises ten chapters headed: Instruments and Materials; The Use of Instruments; Methods of Procedure in Drawing; Lettering; Drawing-room Practice and Conventions; Projection; Mechanical Drawing Practice; Geometrical Problems; Mensuration; Reproduction of Drawings.

The Model T Ford Car. By Victor W. Page. 288 pages, 5 by 7½ inches. 94 illustrations. Published by the Norman W. Henley Publishing Co., New York City. Price, $1.

This book is a tribute to the success of the Ford car, and it runs on all fours with the accessories manufactured exclusively for the Ford car by many concerns. With the close of the 1915 season's business, there will be probably 600,000 Ford cars of all types in use. This is the only

No. 11 Plain
Grinding Machine



Capacity
To 6" Dia. 32" Long

Our New Self-Contained Plain Grinding Machines

The new design of our Nos. 10 and 11 Plain Grinding Machines means a further increase in the already high operating efficiency of these machines. They are now entirely self-contained, having single pulley constant speed drives that do away with complicated overhead works. This adapts them particularly well to a motor drive.

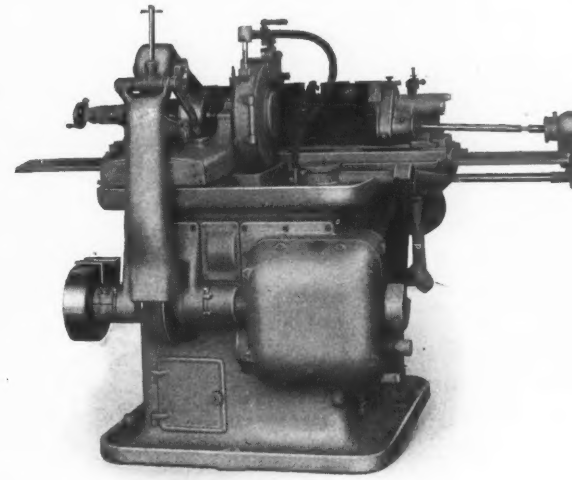
Efficient features of previous designs, such as the multiple friction disk variable speed mechanism and the automatic cross feed, are still retained. Thus in addition to a simplified and more efficient drive there is a wide range of speeds and feeds from which the most productive combination can be quickly selected. The automatic cross feed can be set to reduce pieces to a predetermined size and automatically disengage without attention from the operator, thus allowing him to prepare work or run other machines while a piece is being ground. If you are interested in the type of grinding efficiency that means saving time and money, the following features of these machines are worth your careful consideration:

BROWN & SHARPE MFG. CO.,

OFFICES: 20 Vesey St., New York, N. Y.; 654 The Bourse, Philadelphia, Pa.; 626-630 Washington Blvd., Chicago, Ill.; 305 Chamber of Commerce Bldg., Rochester, N. Y.; Room 419, University Block, Syracuse, N. Y.

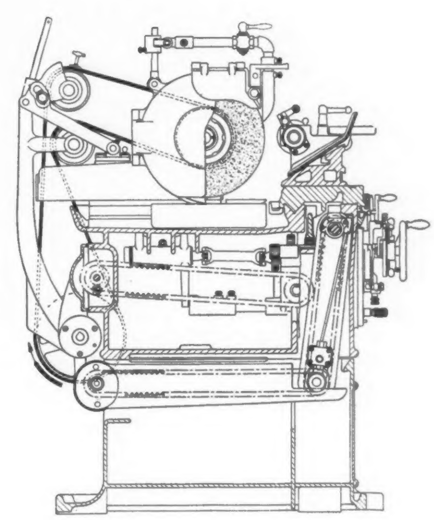
REPRESENTATIVES: Baird Machinery Co., Pittsburgh, Pa., Erie, Pa.; Carey Machinery & Supply Co., Baltimore, Md.; E. A. Kinsey Co., Cincinnati, O., Indianapolis, Ind.; Pacific Tool & Supply Co., San Francisco, Cal.; Strong, Carlisle & Hammond Co., Cleveland, O., Detroit, Mich.; Colcord-Wright Machinery & Supply Co., St. Louis, Mo.; Perine Machinery Co., Seattle, Wash.; Portland Machinery Co., Portland, Ore.

Main Drive



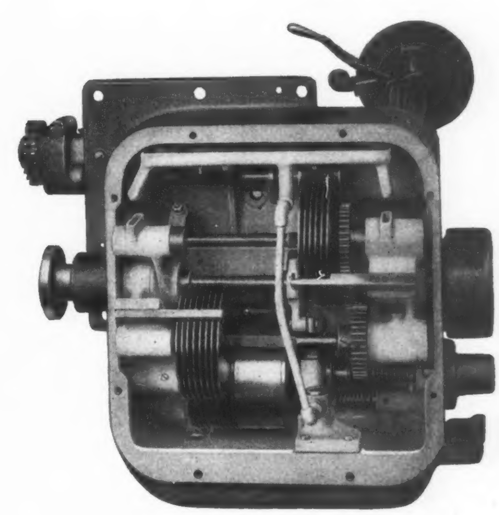
The rear view of one of these machines shows the main driving shaft. This shaft runs in ball bearings. The driving pulley at the left end carries a 3" belt and runs at 900 R. P. M., the high speed and large belt contact insuring ample power. The large pulley located near the center of the shaft drives the wheel spindle. The variable speed case is shown, this also being directly coupled to the main drive. Note the liberal size of the bearings of the driving shaft.

Wheel Drive



The accompanying line cut illustrates the general arrangement of the drive throughout these machines and shows the manner of driving the wheel. A 3" belt runs from the large pulley on the main shaft over a pair of idler pulleys to the wheel spindle. These idler pulleys are carried in a swinging arm so connected to the wheel stand that the cross travel of the wheel does not alter the belt tension nor interfere with the accurate feeding of the wheel. Varying wheel speeds are obtainable by means of split pulleys which can be quickly clamped on the wheel spindle. One of the idler pulleys can be adjusted to take care of the difference in belt tension when pulleys are changed. The location and arrangement of the silent chains which form a part of the

Head-stock and Table Drive



are also shown. These chains are driven by sprockets from the variable speed mechanism, the upper chain driving the table, the lower chain, in conjunction with the one running vertically, driving the head-stock through a splined shaft, a telescopic shaft and universal joints. This drive is shown at the right side of the machine in the top picture. The cut showing the interior of the variable speed case gives an excellent view of the arrangement of the multiple friction disks which give the smooth and powerful drive for the table and head-stock.

Write for descriptive literature.

PROVIDENCE, R. I., U. S. A.

CANADIAN: The Canadian-Fairbanks-Morse Co., Ltd., Montreal, Toronto, Winnipeg, Calgary, Vancouver, St. John, Saskatoon.

FOREIGN: Buck & Hickman, Ltd., London, Birmingham, Manchester, Sheffield, Glasgow. F. G. Kretschmer & Co., Frankfurt, a/M., Germany; V. Lowener, Copenhagen, Denmark, Stockholm, Sweden, Christiania, Norway; Schuchardt & Schutte, Petrograd, Russia; Fenwick Freres & Co., Paris, France; Liege, Belgium; Turin, Italy; Zurich, Switzerland; Barcelona, Spain; The F. W. Horne Co., Tokio, Japan; L. A. Vail, Melbourne, Australia; F. L. Strong, Manila, P. I.

READ PAGE 67

make of motor vehicle in the world that is sold in sufficient quantities to warrant the publication of a special treatise on its repair and maintenance. The work deals with the car, its parts, their functions, the engine and auxiliary groups, details of the chassis, driving and maintenance of Ford cars, and overhauling and repairing the mechanism. It was prepared especially for Ford drivers and owners, and was written by an owner who has driven and repaired a Ford car for a number of years. The illustrations were made especially for the work, and are not to be confused with the illustrations used by the manufacturer in his general literature.

Practical Applied Mathematics. By Joseph W. L. Hale. 206 pages, 4½ by 7 inches. 184 illustrations. Published by the McGraw-Hill Book Co., New York City. Price, $1.

This work is intended for public, private, trade, vocational schools, and corporation schools of manufacturing industries and railroads. It is based on the author's experience in the organization and development of schools for railway shop apprentices. He found no text-book suitable for these schools, and to meet the needs of his pupils, a series of instruction sheets were developed. The book deals with the simple mathematical fractions; decimals; percentage; ratio and proportion; measurement of angles; mensuration of rectangles and other four-sided figures; mensuration of triangles; the circle; mensuration of simple solids; use of rules and formulas; simple equations; the binomial; use of tables and curves; cube root; mensuration of prisms, pyramids and cones; mensuration of miscellaneous solids; miscellaneous rules for polygons; miscellaneous rules for length, area and volume; and the metric system of measurement. Each chapter contains a number of practical problems involving quantities of materials used by railways or manufacturers.

Lathes: Their Construction and Operation. By George W. Burley. 231 pages, 4½ by 7¼ inches. 200 illustrations. Published by Scott, Greenwood & Son, London, and D. Van Nostrand Co., New York City. Price, $1.25, net.

This work by a well-known British contributor to MACHINERY was written with the object of presenting a survey of the whole field of lathe construction and operation from the descriptive point of view. Necessarily, therefore, the treatment is elementary, because of the extensiveness of the subject and the limitation of space. It deals with the evolution of the lathe, the classification of modern lathes, hand turning lathes, engine lathes, turret lathes, vertical lathes, special lathes, lathe accessories, lathe cutting tools, lathe work, cutting speeds and feeds, and contains an appendix of tables as follows: List of screw threads that can be cut on Hendey-Norton lathe; list of change gear wheels for cutting English threads; and list of change gear wheels for cutting metric threads. The book should be useful to those wanting a general survey of lathes used for metal turning, students and others interested in metal-working machinery. The machinist will find useful information on lathe construction and descriptions of accessories, some of which are not in common use in America.

Experiences in Efficiency. By Benjamin A. Franklin. 167 pages, 5 by 7½ inches. Published by the Engineering Magazine Co., New York City. Price, $1.

This book by Mr. Franklin gives specific examples of efficiency methods and the saving resulting from the adoption of the same, as noted in his experience. A few weeks' study of the workmen's tendencies in a certain factory effected a saving of about $30,000 yearly. Nothing was spent for new equipment, nor was any change made in the organization and personnel. The saving was effected by correcting wrong conditions—in other words, by reorganizing the methods. The author begins with that which is generally uppermost in the manufacturer's mind—the handling of labor. Four chapters are given over to methods of increasing both output and quality of direct production. The fifth chapter extends the same principle to the treatment of clerical or non-productive labor, and the sixth enlarges the same ideas applied to include the entire force. Then follow chapters on increase in production by a simple reorganization, reducing the factory expenses, building a cost system, and the necessity of efficiency will. This work forms a unit of the Engineering Magazine Co.'s works management library.

Modern Toolmaking Methods. Compiled and edited by Franklin D. Jones. 309 pages, 6 by 9 inches. 176 illustrations. Published by the Industrial Press, New York City. Price, $2.50.

Considering the fact that the work of the toolmaker requires an unusual degree of skill and refinement and that it is of great importance in interchangeable manufacture, it is surprising to note how little has been published on toolmaking practice. This volume of "Modern Toolmaking Methods" is, therefore, believed to meet a real need, as it deals with a great variety of tool-room problems and explains many important toolmaking operations. Some of the methods described represent standard practice, whereas a great many are of special operations that have been developed in different shops. The treatise covers quite completely the methods and operations which are fundamental and essential to the production of small tools and precision work. It also contains many valuable rules, simple formulas and typical calculations that will aid in the solution of the practical problems met with in the tool-room. As accuracy is essential to all toolmaking operations, the various methods for locating, spacing and dividing precision work have been made a special feature in this book. The book is divided into eight chapters, headed as follows: Precision Locating and Dividing Methods; Laps and Lapping; Straight and Circular Forming Tools; Precision Threading; Threading Chaser Troubles and Remedies; General Toolmaking Operations; Precision Bench Lathe Practice; Gages and Measuring Instruments.

Combined Power and Heating Plants. By Charles L. Hubbard. 408 pages, 6 by 9 inches. 220 illustrations. 98 tables. Published by McGraw-Hill Book Co., New York City. Price, $3.

This work is Part III of a series of three volumes on "Power, Heating, and Ventilation," the first of which deals with "Steam Power Plants" and the second with "Heating and Ventilating Plants." This third part on "Combined Power and Heating Plants" relates especially to power and heating equipment for large buildings, such as office buildings, department stores, hotels, machine shops, foundries, and factory buildings in general. The various problems have been treated broadly and with special reference to the steam requirements. The equipment relating to the generation and use of steam has been considered in detail. It is assumed that the user of this book is already familiar with the common details of heating and ventilation, and, hence, attention has been given only to such special requirements as may be met with in the buildings under consideration. The various steps in the design of power and heating plants for the service referred to have been taken up in logical order, and computations worked out in detail to show their application to special requirements. The twelve chapters of the book are headed as follows: Heating and Ventilating Requirements for Different Types of Buildings; Working Data for Steam and Hot-water Heating; Working Data for Hot-blast Heating and Ventilation; Central Plants; Power and Steam Requirements for Different Types of Buildings; The Boiler Plant; Steam Engines and Turbines; Auxiliary Equipment; Piping for Power Plants; Combined Power and Heating; Equipment and Operating Costs; Practical Examples in Design and Cost of Operation.

Valves and Valve Gears. By Franklin De Ronde Furman. 253 pages, 6 by 9 inches. 300 illustrations. Published by John Wiley & Sons, Inc., New York City. Price, $2.50.

This is the first volume of a work in two volumes on valves and valve gears, the first volume pertaining to steam engine and steam turbine valves. The author, who is professor of mechanism and machine design at Stevens Institute of Technology, first published a set of mimeographed notes in 1903 on this subject, and the present work has developed on the basis of these notes. A feature of the work is that all types of practical valves for steam engines and turbines have been segregated into seven fundamental forms, and the valve gear constructions have been grouped into six fundamental types. This gives the whole subject a logical arrangement. The book is divided into eight specific sections, headed as follows: Elementary Reciprocating Steam Engines, Valve Diagrams for Steam Engines, Fundamental Valve Forms, Fundamental Valve-gear Mechanisms, Practical Types of Valves for Reciprocating Steam Engines, Eccentrics and Shaft Governors for Steam Engines, Practical Steam Engine Valve Gears, and Steam Turbine Valve Gears. Much of the material in this work is based on visits to works and construction offices, in which the work in valve gears is carried on in a practical and commercial way, and it is therefore believed that the methods presented in this book will be found to agree closely with general practice. It has been made a rule to have the manufacturer of the valve gear or engine described pass upon the accuracy of the description and the illustrations that appear in this work. This gives the book an unusual stamp of authority, and it should prove useful both to students and designers of engine and turbine valves and gears.

Tools, Chucks and Fixtures. By Albert A. Dowd. 304 pages, 6 by 9 inches. 186 illustrations. Published by the Industrial Press, New York City. Price, $2.50.

This book comprises a comprehensive and detailed treatise covering the design and use of cutting tools and holding devices employed in turning and boring operations in modern manufacturing plants, for obtaining accuracy and increasing production. The book comprises mainly the articles on tools and holding devices for engine and turret lathes, and horizontal and vertical boring machines, which have been published in MACHINERY during the past year by the author. These articles have been recognized as constituting the most fundamental and complete descriptions of tools and devices for machining operations ever published, and have, therefore, been collected and are now published in this volume. In addition to the chapters applying specifically to boring and turning operations, considerable attention has been paid to the design of tools and holding devices relative to the cost of keeping them in repair—considerations which are of prime importance in economical shop management. Perhaps the most valuable feature of this book is that the arbors, chucks, fixtures, and other holding devices shown are illustrated complete with their working details, and not merely in diagrammatic form, and also that these devices are examples of designs actually employed in practice and successfully applied to productive work in a great number of manufacturing establishments. The descriptions of the tools are in plain matter-of-fact statements and will appeal with especial force to the great body of men of practical training who are seeking specific and up-to-date information. It is the belief of the author and the publishers that the work fills a well-defined gap in existing mechanical literature, and that the direct and definite method by which the information is conveyed to the reader will meet with the approval of the trade for which this book has been prepared. The contents are divided into a number of chapters, each covering one particular phase of the subject. The headings of the chapters are as follows: Adjustable and Multi-cutting Turning Tools; Design of Boring Tools; Recessing Tools; Floating Reamer Holders; Arbors for Turning, Boring and Grinding; Holding Devices for Lathe and Boring Mill Work; Methods of Machining Thin and Irregular Work; Taper Boring and Turning Attachments; Machining Convex and Concave Surfaces; Methods for Machining Eccentric Work; Counterbalanced and Indexing Fixtures; Influence of Chips on the Design of Tools and Fixtures; Providing for Upkeep in the Design of Cutting Tools.

Text-book of Advanced Machine Work. By Robert H. Smith. 520 pages, 5 by 8 inches. 609 illustrations. Published by the Industrial Education Book Co., Boston, Mass. Price, $3.

This text-book has been prepared by the author, who has charge of the machine shops of the Massachusetts Institute of Technology, with a view to meeting the demand for a text-book in machine work for students in technical, manual training and trade schools, and for apprentices in machine shops. In his preface, the author calls attention to the fact that text-books have been prepared for the study of languages and all the sciences, whereas teachers and students of machine shop work, apprentices and machine operators, have been handicapped by the lack of text-books comparable with those that aid the student and teacher in other subjects, and for this reason he has prepared two text-books—one on "Principles of Machine Work" and one on "Advanced Machine Work"—the book under review being the latter of the two. In his book on advanced machine work, the author treats of engine lathe work, cutting tools, measuring, turning, fitting, threading, chucking, reaming, mandrels or arbors, curve turning and forming, inside calipers and inside micrometers, boring and inside threading, brass finishing, broaching, drilling jigs, boring, boring-bars and boring machines, eccentric turning, knurling, cylindrical, internal, surface and cutter grinding, planing, milling, spur, bevel, worm and spiral gear cutting, toolmaking, spiral milling, the plug and button methods of locating holes of precision in jigs and fixtures, and sine bars.

The book differs from the ordinary descriptive work on machine tool operation in that it is arranged strictly as a text-book, giving specific "problems" of work to be turned out by the student. The whole subject has been analyzed and arranged so as to afford a gradual step-by-step training in machine work, much the same as the student would be taught mathematics or mechanics by a simple orderly method. Machines, mechanisms and tools are illustrated mainly by perspective drawings so that the student who is not familiar with mechanical drawing may be able to get a comprehensive idea of the object represented. The drawings are, in many cases, so clearly marked with explanatory words and letters that many of them show the operations and processes involved more clearly than would an explanation in words. In addition, the book contains a great number of valuable tables and compilations of data that make it suitable for a reference book. In order to make reference to any particular part convenient, a very complete index is attached. The book is divided into twelve sections, each of which has the page number of the section preceded by the section number, this being a new idea in the arrangement of a book of this character. The instructor who is organizing a course will find a text-book of this character very valuable, because no lectures could possibly be as complete as is this book, and the data and illustrations will prove very useful to the student for study between the lectures. The whole arrangement of the book is founded on the author's thirty years' experience and study of the subject. The increased efficiency obtained at the Massachusetts Institute of Technology, by the use of these text-books, justifies high praise for them.

NEW CATALOGUES AND CIRCULARS

Bemis & Call Hardware & Tool Co., Springfield, Mass. Leaflet listing the line of wrenches manufactured by this company.

Dover Boiler Works, 50 Church St., New York City. Pamphlet of Dover rust-proof enameled tanks, guaranteed against rust.

Hanna Engineering Works, Chicago, Ill. Catalogue 3, describing and illustrating pneumatic riveters made by this company.

Allen-Bradley Co., Milwaukee, Wis. Bulletin B-54 on type H resistance starting switch for alternating current induction motors.

Hisey-Wolf Machine Co., Cincinnati, Ohio. Bulletin 1402-A on heavy-duty portable surface electric grinders, direct-current only.

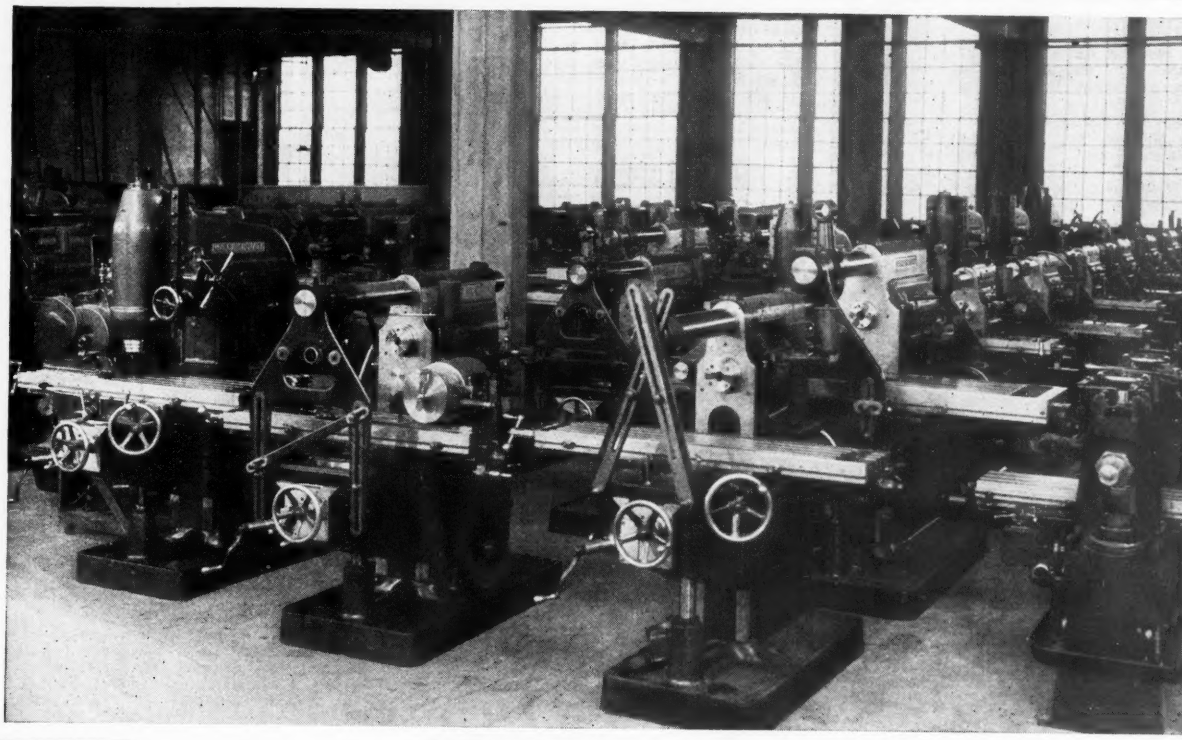
Harvey Hubbell, Inc., Bridgeport, Conn. General catalogue 15, containing 175 pages, 5 by 6 inches, devoted to electrical specialties of all kinds.

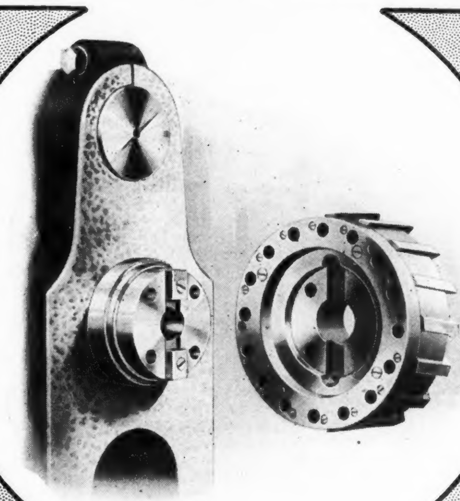
National Machinery Co., Tiffin, Ohio. Tapper Talk No. 3, illustrating the National automatic bent tap nut tapper that will tap nuts from 3/16 to ¾ inch.

Charles H. Besly & Co., 120 B. North Clinton St., Chicago, Ill. Pamphlet on the Besly disk grinder, illustrating the wide variety of work for which this machine is adapted.

Lucas Machine Tool Co., Cleveland, Ohio. Booklet "Saving Set-Ups in Railroad Shops," showing how the Lucas precision boring, drilling and milling machine is adapted for railroad work.

Lamson Co., 161 Devonshire St., Boston, Mass. Folder illustrating systems of the Lamson carrier or conveyor for effecting rapid transportation and quick communication inside factories, offices, etc.





Shore Instrument & Mfg. Co., 555-557 West 22nd St., New York City. Circular of the Shore "durometer" and "elastometer" for measuring the hardness and elasticity of rubber and other pliable materials.

Chicago Flexible Shaft Co., 149 W. La Salle St., Chicago, Ill. Catalogue 56 of Stewart gas and oil gas furnaces for the heat-treatment of metals, and positive pressure blowers and pyrometers.

Abrasive Material Co., Philadelphia, Pa. Booklet on "Boro-carbone," a new abrasive composed of oxide of alumina in crystalline formation, produced by fusing bauxite in an electric furnace by the arc process.

National Machinery Co., Tiffin, Ohio. "Tapper Talk No. 2" deals with the "National" automatic (bent tap) nut tapper, for which the advantages of bigger output, longer tap life and less tap breakage are claimed.

National Machinery Co., Tiffin, Ohio. Tapper Talk No. 4 "Why the Bent Tap Principle Makes the Ideal Automatic Nut Tapper." The bent tap principle enables the machine to run continuously in one direction.

Ingersoll Milling Machine Co., Rockford, Ill. Bulletin 32A containing a number of layouts illustrating methods employed by motor manufacturers in milling gas engine cylinders and crank cases on Ingersoll milling machines.

Bristol Co., Waterbury, Conn. Booklet of Bristol recording instruments distributed at the Panama-Pacific Exposition as a souvenir of the twenty-fifth anniversary of the manufacture of Bristol recording instruments.

Gem Mfg. Co., Pittsburg, Pa. Catalogue 8 of the products manufactured by this company, which include brazed seam oilers and torches, foundry chaplets, flue scrapers, flexible shafting, special dies, metal stampings and specialties.

Peerless Machinery Co., 45 Binford St., Boston, Mass. Leaflet advertising the "safety" toolholder. This tool will hold drills or reamers from 1/4 to 1 1/4 inch, and will drill a perfectly true and parallel hole because of its floating feature.

Ingersoll-Rand Co., 11 Broadway, New York City. Bulletins 3031 and 4034 on the new Ingersoll-Rogler, class FR-1 steam-driven single-stage staight-line air compressor, and the type 26 Leyner-Ingersoll water drill, respectively.

Lucas Machine Tool Co., Cleveland, Ohio. Booklet entitled "Saving Set-Ups." This booklet describes the work for which the Lucas precision boring, drilling and milling machine is adapted, and illustrates this machine in operation on a wide variety of work.

Neil & Smith Electric Tool Co., Cincinnati, Ohio. Catalogue of portable electric tools, comprising variable and constant speed grinders, buffers, drilling machines, screw-drivers, portable flexible shaft screw-drivers, and portable direct-connected circular saws.

H. D. Smith & Co., Plantsville, Conn. Leaflet on the "enchased" joint slot-cutting pliers, which are provided with a new type of joint that has a bearing around its entire circumference except where there is an opening for a cutter. These pliers are made in 6-and 8-inch sizes.

The Bourse, Philadelphia, Pa. Circular illustrating the machinery exhibition hall and salesroom. The Bourse which is the machinery center of Philadelphia contains, besides the machinery exhibition and salesroom, about 450 offices, affording manufacturers office facilities convenient to the exhibition hall and salesroom.

Mesta Machine Co., Pittsburg, Pa. Horsepower chart for power transmission machinery, including gears, pulleys, rope wheels, etc. The chart is printed in small scale on a 9- by 12-inch page, but a large blueprint of it can be obtained from the company by engineers and others concerned with transmission problems.

Turbo-Gear Co., Industrial Bldg., Baltimore, Md. Circular of the "Turbo-gear" speed transformer, consisting of a planetary herringbone gear combination for reducing the speed of high-speed shafts. These gear transformers are made for various speeds from 500 to 6000 R. P. M., and various ratios from 1 to 16, to 1 to 85.

Cooper Hewitt Electric Co., Hoboken, N. J., has begun the publication of a house organ entitled, "The Output." The magazine is devoted to increasing production in manufacturing and other industries by the use of better lighting facilities. The leading article in the May number is "Lighting of a Punch Press Room," by Theodore D. Pratt.

Reynolds Pattern & Machine Co., 101-103 Third Ave., Moline, Ill. Catalogue of the Reynolds automatic screw-driving machine for wood or machine screws. These are made in a variety of styles including machines with magazine feed and boring attachments, magnetic chucks, extension heads, etc.

National Machinery Co., Tiffin, Ohio. "National Forging Machine Talk No. 7" discusses the subject of protecting forging machines from damage from the gripping mechanism, and describes the automatic relief device provided on the gripping dies of "National" forging machines. The halftone and line illustrations make the construction very clear.

Ready Tool Co., 654 Main St., Bridgeport, Conn. Leaflet descriptive of the "Red-E" belt-shifting pole which has been designed to eliminate the accidents that happen when an operator is obliged to climb a ladder and put on or take off a belt by hand. This belt-shifting pole complies with the requirements of the various state compensation acts.

Eck Dynamo & Motor Co., Belleville, N. J. Bulletin 1000 illustrating and describing a new line of direct-current motors known as type D. These motors have several new features incorporated in their design, among which might be mentioned the use of commutating poles, positive ventilation by internal fans, and the employment of self-aligning ball bearings.

Chicago Pneumatic Tool Co., Chicago, Ill. Circular of the Chicago pneumatic banding press for compressing the copper bands on shrapnel shells. This press sets the bands on an 18-pound shrapnel shell in from seven to eight seconds, and its production with one operator is about one shell per minute, and with two operators from three to four shells per minute.

Keuffel & Esser Co., Hoboken, N. J. General catalogue, 566 pages, 5 1/2 by 8 1/2 inches (thirty-fifth edition), listing the complete line of drawing materials, surveying instruments and measuring instruments made by the company. The draftsman should find this book of considerable value, as it lists all the instruments and other paraphernalia that he might need in connection with his work.

National Tube Co., Pittsburg, Pa. Catalogue J of pipe fittings, valves and specialties manufactured at the Kewanee works of the company. The catalogue contains 450 pages, 5 by 7 1/2 inches, and the index embraces approximately 1800 entries. The edition of this catalogue is strictly limited and it will be sent only to officials, purchasing agents and others responsible for the ordering of supplies.

Chicago Pneumatic Tool Co., Fisher Bldg., Chicago, and 52 Vanderbilt St., New York City, has issued Bulletin 34-X on class A-G "Giant" gas and gasoline engines. The bulletin illustrates these engines in six sizes, ranging from 16 to 130 H. P. The engines are similar in general design to the "Giant" fuel oil driven engines manufactured by the same company, except that they are designed for operating with manufactured and natural gas.

New Departure Mfg. Co., Bristol, Conn. Bulletins 8 and 9, constituting loose-leaf catalogue data sheets of "New Departure" ball bearings and their applications to machinery. Bulletin 8 illustrates ball bearing mountings for multi-stage turbine pumps, and Bulletin 9, ball bearing installations for light mine car wheels. A loose sheet table of contents, frequently revised, is also furnished for the convenience of users of data on these ball bearings.

Newton Machine Tool Works, Inc., 23rd and Vine Sts., Philadelphia, Pa. Catalogue 49 illustrating the complete line of Newton standard and special slotters. The smaller sizes are crank driven, while the larger sizes are driven by screw or by rack and pinion. These machines are built to be driven by belt, pneumatic clutch or reversible motor. A few of the different designs of milling, boring, drilling and cold-saw cutting-off machines are also shown.

Detroit Twist Drill Co., 600-612 Fort St. West, Detroit, Mich. Booklet on the new "Detroit" quick-twist drill, including miscellaneous tables and general information for users of twist drills. The "Detroit" quick-twist drill is a departure from the common form in which the angles of the flutes are 25 degrees at the point and 20 degrees at the shank. The angles of the flutes of quick-twist drills are 27 and 32 degrees, respectively. The claim is made that a more acute cutting edge, larger chip space and freer action are secured by this change.

Willy Lamot, Shardhighs, Halstead, Essex, England, is forming an organization of Belgian business men, having for its object the introduction in Belgium when the war is over of American products, machines, etc., and the employment as agents, representatives, etc., of Belgian manufacturers and business men who were partly ruined but still possess sufficient capital and can give the necessary guarantees. American manufacturers interested in this prospective outlet for their products are invited to correspond with Mr. Lamot.

Blanchard Machine Co., 64 State St., Cambridge, Mass. Bulletin of the direct motor drive type of Blanchard high-power vertical surface grinder. A standard motor is incorporated in the wheel-head of the machine, thus giving a compact and efficient drive. Simple means of forced ventilation are provided in the motor, which tends to prevent dirt from entering and keeps the motor temperature low, even when operated at heavy overloads. Details of the motor construction are shown, and an example of work for which this type of vertical machine is adapted.

Globe Machine & Stamping Co., Cleveland, Ohio, has issued an interesting booklet entitled "A Trip through the Globe Shop," which is illustrated with views of the offices and various shops included in the plant. A glance through the book will give an idea of the diversity of work done by this company. The product includes stampings of all kinds, sheet metal work, metal boxes for automobiles, steel reels and beams, tumbling barrels, etc. A cordial invitation is extended to all interested to visit the Globe shops and see for themselves the character of the work done.

General Electric Co., Schenectady, N. Y. Bulletin 41013 on direct-current commutating pole motors, type RC. These motors have cast steel frames of medium weight and symmetrical section. They may be used with a sliding base which maintains a correct driving alignment and which, with the adjustable shields, permits the installation of the motor on the floor, wall or ceiling. They may be equipped with covers, rendering them semi-enclosed, totally enclosed or self-ventilated. They are wound for 115, 230 and 550 volts direct-current circuits, with permissible voltage range of from 110 to 125, 220 to 250, and 500 to 600 volts.

Charles Stecher Co., Chicago, Ill. Catalogue of automatic can-making machinery and machine tools, comprising lock-seam can-body making machines, wire bail forming machines, can earing machines, ear assembling machines, ear crimping machines, handle riveting machines, horning and wiring presses, beading and flanging machines, false wiring chucks, double seaming and false wiring machines, double seamers, crimping machines, folding and edging machines, heading and squeezing machines, square can machines, handle soldering machines, testing machines, ear sweating machines, ear coating machines, rivet spinners, screw presses, bench drilling machines, etc.

American Express Co., 65 Broadway, New York City. Booklet entitled, "What the American Express Co. Meant to Americans in Europe During the War." The foreign organization of the American Express Co. embraces Great Britain, France, Germany, Italy, Scandinavia, Holland and Belgium. The intention is to establish branches in Buenos Aires, Manila, Hong Kong and other important cities in the Far East also. The company will cooperate with the sales department of American manufacturing concerns on ways and means of entering the foreign countries in which it operates. These and other services are offered for the promotion of American foreign trade.

TRADE NOTES

Buissono Bros. Mfg. Co., 3351 Parnell Ave., Chicago, Ill., has removed to its new plant located at this address.

John MacNab Machinery Co. has removed its office from 154 Chestnut Ave., Jersey City, N. J., to 90 West St. (West St. Bldg.), New York City.

L. W. Randolph, Inc., 9-15 Clinton St., Newark, N. J., has been licensed to manufacture the Tygard reversible and non-reversible rotary steam engine.

Max Ams Machine Co., builder of sanitary can machinery, presses, dies, special machinery, etc., has moved its works from Mount Vernon, N. Y., to Bridgeport, Conn.

Independent Pneumatic Tool Co., Chicago, Ill., has appointed George C. Wilson manager of the company's Atlanta, Ga., branch in place of F. H. Charbono, who has been transferred to Boston.

Lumen Bearing Co., Buffalo, N. Y., announces that Prosper J. Hoeffler has been employed to sell the full line of babbitts and solders which the company has developed during the past fifteen years.

J. N. Lapointe Co., New London, Conn., has begun the erection of an addition 40 by 80 feet, two stories high, constructed of concrete and brick. The upper floor will be used for a hardening room.

Standard Drafting Service, 142 Market St., Newark, N. J., announces that it is prepared to make drawings, tracings, charts, forms, specifications, etc., for all engineering, contracting and mercantile work.

Fafnir Bearing Co., New Britain, Conn., manufacturer of ball bearings, has opened an office in the David Whitney Bldg., Detroit, Mich., to take care of Ohio, Indiana, and Michigan business. M. Howard Cox is the manager.

Pullman Automatic Ventilator Mfg. Co., York, Pa., has placed on the market a small ready-to-run exhaust ventilator, electrically driven. A descriptive booklet has been issued illustrating the device, giving capacity, etc.

Powers-House Co., 724-725 Illuminating Bldg., Cleveland, Ohio, succeeds the M. K. Powers Advertising Co. The business of the company is technical advertising, preparing house organs, booklets, catalogues, folders, etc.

Hoskins Mfg. Co., 459 Lawton Ave., Detroit, Mich., maker of electric furnaces, pyrometers and heating appliances, has appointed W. C. Tharp district manager in charge of its Pittsburg office, to succeed I. J. Shults, resigned.

Nazel Engineering Works, 4043 N. Fifth St., Philadelphia, Pa., has purchased the electric riveter business of the Eveland Engineering & Mfg. Co., Philadelphia, Pa. The Eveland riveter softens the rivet head by electric heat and then upsets by pressure.

Burd High Compression Ring Co., Rockford, Ill., has increased its capital stock from $50,000 to $200,000. The additional capital was voted for the purpose of adding to the equipment and enlarging the business to take care of the large contracts recently made for piston rings.

Tropenas Converter Co., 50 Church St., New York City, has begun the erection of a new office and laboratory building in Brooklyn, N. Y. Sufficient ground has been purchased to provide room for a small experimental plant also. In this experimental plant a new steel-producing method will be developed which will be put on the market at an early date.

Nordberg Mfg. Co., Milwaukee, Wis., announces that E. W. Swartwout, formerly of the Chicago office, will be associated after June 1 with Mr. MacLaren in the New York office of the company. Larger offices have recently been taken in the new Equitable Bldg., 120 Broadway, New York City. The Chicago office of the company will be in charge of John E. Lord.

Prest-O-Lite Co., Inc., Indianapolis, Ind., maker of acetylene lighting systems, oxy-acetylene welding and cutting equipment, etc., has entered the electric lighting field, having placed the "Prest-O-Lite" storage battery on the market. The plant of the Pumpelly Battery Co. in Indianapolis has been purchased, and for the present the storage battery will be produced by the Pumpelly plant.

Harvey Co., Inc., 113 South St., Baltimore, Md., has been incorporated under the laws of Maryland to sell supplies and equipment to railroads, con-

tractors, plants, industrial establishments, ship and engine building companies, etc. J. Edward Harvey, president of the company, was formerly vice-president of the South Baltimore Steel Car & Foundry Co., and was also proprietor of the Eastern Railway Supply Co.

Cowan Truck Co., Holyoke, Mass., held an annual gathering of its salesmen at the company's plant in Holyoke, June 7 and 8. Over twenty-two delegates representing the company throughout the United States were present to participate in both the social and business features of the gathering. Announcement was made of the new low-priced Cowan transveyor which is to be placed on the market immediately.

Ingersoll-Rand Co., 11 Broadway, New York City, has opened a branch office in San Francisco, Cal., at 139 Townsend St., with a view to giving more attention to present and prospective users of Ingersoll-Rand machinery than is possible through an agency. H. L. Terwilliger has been appointed district manager for the territory handled by the San Francisco and Los Angeles offices, with headquarters in San Francisco.

Cleveland Twist Drill Co., Cleveland, Ohio, publishes a house organ called "Drill Chips." The June number is devoted to cooperation, and the subject is handled in a decidedly breezy manner. Cooperation presented in this light may be studied with profit by many business men who believe that "competition is the life of trade." The editor closes with the statement: "Competition is colossal human ignorance opposing the cosmic law of cooperation."

S. K. F. Ball Bearing Co., New York City, has recently increased its office space in the Hudson Terminal Bldg., having within the last four months about doubled same. It now occupies a full wing on the sixth floor of the 50 Church St. building. The company's importations from Europe have not been interfered with by the war, as the S. K. F. bearings are made in Sweden, which is a neutral country. The bearings are made in Gothenburg in a factory employing three thousand people, engaged exclusively in the manufacture of S. K. F. ball bearings.

Allied Machinery Co. of America, 55 Wall St., New York City, has placed orders with the Robbins Machine Co., Worcester, Mass., that will keep the concern busy for a year or more. The company has taken larger quarters in Paris at 19 Rue Rocroy, where a large showroom and facilities for demonstrating machines will be available on the first floor. The offices will be on the second floor. This location is central, and convenient to an important railway terminal. American machine tool builders in Paris are invited to visit the Paris office when in France.

Central Steel Co., Massillon, Ohio, lighted the furnaces in its new $2,000,000 open-hearth steel plant June 8, and poured its first heat of steel—approximately 60 tons—the same day. Heats of high-grade quality, soft basic open-hearth steel have been taken off continuously since. The company's blooming mill was put into operation June 10; it is asserted that the billets rolled were the first ever rolled on an all electrically driven and operated blooming mill in this country. The company's product consists of open-hearth billets, slabs and sheet bars as well as billets composed of various grades of nickel, vanadium and chrome steel.

Hoover Steel Ball Co., Ann Arbor, Mich., has broken ground for a new building 40 by 313 feet, which will be the third that the company has erected since September 1, 1914. The three new buildings comprise a total of 29,000 square feet of floor space, and furnish room for the employment of 500 or 600 people. The new building will be occupied entirely by machinery for making "micro-chrome" balls, contracts having been let for approximately $65,000 worth of additional special ball-making machinery. The large orders for the micro-chrome steel balls received since January 1, when they were placed on the market, have far exceeded expectations, and make these additions to the facilities imperative.